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EAST BOSTON RAPID TRANSIT, says the Boston "Globe," is practically assured. After finishing the present sections of the subway the Subway Commissioners will have about $2,000,000 remaining which can be utilized for building a tunnel to East Boston. It now takes from 35 to 55 minutes to go from East Boston to the City Hall in Boston proper, while a tunnel on the lines proposed would enable the same trip to be made in 6 or 8 minutes. Estimates made upon the tunnel scheme range from $3,000,000 to $7,000,000, according to the plan adopted.

THE LARGEST STEAM POWER PLANT in the world, it is stated, will be erected by the Metropolitan Traction Co., at 96th St. and 1st Ave., New York city. The five north-and-south and the two cross-town street railways operated by the company are to be run by electric current furnished from this one central station, which is expected to have a total capacity of 70,000 HP. The location has been selected on account of its being on the water front, thus avoiding cartage of coal and ashes.

THE NICARAGUA CANAL COMMISSION has resumed its sessions, as Capt. O. M. Carter has returned from Europe, where he went to attend the International Association for the Testing of Materials. Admiral Walker has applied for a government vessel to convey the surveying party to Nicaragua, and it is said that the "Dolphin" will be detailed for this purpose.

MANCHESTER SHIP CANAL TRAFFIC, for the half year ending June 30, 1897, is reported as follows, in comparison with the corresponding traffic of 1896:

	1896.	1897.
Toll-paying traffic, sea-going, tons.....	667,952	783,280
" " barges, tons..	155,127	173,930
" " total, tons.....	823,079	957,210
Increase in gross revenue over 1896.....		$90,575
Increase in net revenue over 1896.....		$32,675

The reduction in net revenue is charged to exceptional expenditures, as $18,830 was paid for damages by fire to the steamer "Twylight," said to have been occasioned by the negligence of the employees of the canal company. A sum of $12,560 was expended in legal charges and there was a loss on dock labor of $15,615 as compared with $4,540 in the corresponding half of 1896. Inadequate shed space and insufficient appliances for handling railway traffic prove very expensive. A grain elevator of 40,000 tons capacity, and more dock sheds, are being erected out of money obtained by selling the perpetual chief rent of the Manchester Ship Canal Pontoons and Dry Docks Co.

THE JAPANESE MERCANTILE-MARINE, according to the British Consul at Tokio, at the end of last year, numbered 448 steamers, aggregating about 360,000 tons, and 113 sailing vessels with a total of about 27,500 tons. Among the steamers are three of 4,000 tons; 14 of from 3,000 to 4,000 tons; 43 of from 2,000 to 3,000 tons, and 67 of from 1,000 to 2,000 tons. During the year the Nippon Yusen Kaisha Co. has opened lines to Europe, Australia and the United States, and has ordered 12 new steamers of 17 knots speed and large carrying capacity.

THE AMERICAN LINE STEAMER "ST. LOUIS" has lowered the record from New York to Southampton to 6 d. 10 h. 14 m., thus beating her own previous best record by 1 h. 10 m., and that of the "Fuerst Bismarck," made in September, 1893, by 41 m. Her sister ship, the "St. Paul," holds the best westward record of 6d. 0 h. 31 m., made in August, 1896.

THE TORPEDO BOAT "RODGERS," one of three boats which were contracted for by the government with the Columbian Iron Works, of Baltimore, Md., has failed for the third time on trial. In the two first trials her machinery broke down, and on Sept. 11 the engines again gave way and Chief Engineer John R. Edwards, U. S. N., and several of the men were scalded. The torpedo boat "Foote," built by the same firm, was successful on a second trial some weeks ago, but in the first trial a fireman was killed and another man injured. Including the "Foote," five torpedo boats are now in commission.

THE GOVERNMENT NAVAL ARMOR BOARD has announced that it has no authority to select a site for or to purchase an armor-making plant. Its instructions confine the work of the board to ascertaining what steps are necessary to establish an adequate government plant, and to furnish plans, specifications and estimates, and to report upon the advisability of establishing a complete plant to be operated by the government.

THE BROOKLYN DRY-DOCK REPAIRS, notwithstanding the practically unlimited authority given Naval Constructor Bowles, are developing some awkward conditions, owing to the manner in which Congress made the appropriation for this purpose. Instead of giving the money in a lump sum the separate expenditures are specified, as follows: For constructing and removing coffer dam, $48,000; repairs to dock as recommended by Board of Survey, $20,000; for contingencies, $22,000. Owing to the fact that the Chief of Bureau of Yards and Docks demanded Florida pine boards 60 to 70 ft. long for the coffer dam, and had to have them specially cut in Florida, the cost of building the coffer dam alone has about consumed all of the $48,000. And under the strict ruling of the financial department of the navy no transfers can be made from one item to the other. As the extent and cost of the actual repairs cannot be ascertained until the coffer dam is pumped out, Chief Naval Constructor Hichborn says that it is extremely likely that more money will be needed for the completion of the work than has been appropriated. It is again apparent that the head of the Bureau of Yards and Docks did not seek proper engineering advice, or take proper engineering precautions in making his estimates for repairs.

A LARGE FLOATING, OR PONTOON DRY-DOCK is described by U. S. Consul Robertson, of Hamburg, Germany. This dock was built for use in connection with the ship-building yard of Blohm & Voss, of Hamburg, but it can be moved and would be available in the Kaiser Wilhelm Ship Canal. It consists of seven pontoons, arranged to be joined together in a connected system, and so assembled it has a length of 624 ft. 4 ins., and a width of 118 ft. 1 in. Two engine and boiler rooms are provided for pumps, electric and hydraulic machines, and these two engines are of the condensing type, and have a capacity of 700 HP. each. They operate 14 pumps, two in each pontoon, which are capable of pumping out the dock in 45 minutes. The dock will accommodate a vessel of 26 ft. draft at its dock, or in sufficiently deep water take a vessel of 29 ft. 6 ins draft, and it is claimed that it has a carrying capacity of 17,500 tons. No information is given as to cost, and the impression is given that it is an awkward structure to move.

ANOTHER FLOATING DRY-DOCK has been completed for the Spanish government, for use at Havana, by Swan & Hunter, of Wallsend, England. This dock was designed by Messrs. Clark and Stanfield, of Westminster, and consists of five pontoons with movable caissons, or end-gates. The three middle pontoons are rectangular in shape and the end pontoons are pointed; all of them being 87 ft. wide, and the middle ones are 75 ft., and the two end ones 108 ft. 4 ins. long, making the overall length of the dock 450 ft. The width between the broad altar steps is 82 ft. and the depth over the sill is 27½ ft. When immersed to this extent the dock draws 42½ ft. of water with a freeboard of 4 ft. 2 ins. Each pontoon can be detached and separately docked for cleaning and repairs. The pumping plant, which is in duplicate, is capable of lifting the dock, with a 10,000 ton ironclad in it, in about 2½ hours. Each pontoon is divided into four water-tight compartments, and the walls below the engine decks are each divided into five such compartments. This dock is to be towed to its destination, and will be fitted, for this purpose, with a foremast and square sails, with a jigger-mast aft, steam steering gear, etc. The manilla hawsers for towing have been especially made for this purpose and are said to be 22 ins. circumference and to be the largest ever made.

THE MOST SERIOUS RAILWAY ACCIDENT of the week and the most serious for many months occurred Sept. 10, at 12.15 a. m., on the Rio Grande Junction R. R., about 1½ miles west of Newcastle, Colo. The number of killed is still uncertain, as the wreck took fire and many bodies were consumed, but seems to have been between 25 and 35, while the number of injured is given anywhere between 50 and 100. The accident was a butting collision between a Denver & Rio Grande west-bound passenger train and a Colorado Midland stock train, which met while running at full speed around a curve. Immediately after the collision the wreck took fire from some cause not yet known and spread so rapidly that the many imprisoned passengers who might have otherwise escaped were cremated before the eyes of the helpless onlookers. It was this which made the list of killed so great. The exact cause of the accident is at present uncertain, but reports tend to place the blame upon the conductor and engineer of the freight. The passenger train was an hour behind time and the freight crew is said to have attempted to reach a passing point beyond that which was given them in their orders.

ANOTHER VERY SERIOUS ACCIDENT occurred Sept. 8 on the Atchison, Topeka & Santa Fe Ry., about three miles east of Emporia, Kan., resulting in the death of 16 persons and the serious injury of fully as many. According to reports, an east-bound express and a west-bound Mexican California express, drawn by two locomotives, collided head on. It is stated that there was a confusion of orders as to the point of passing.

A THIRD SERIOUS RAILWAY ACCIDENT is reported at Sallisaw, Ind. Ty., on Sept. 12. This occurred on the Iron Mountain R. R. and appears to have been due to the trucks of a car, near the head of the train, breaking while the train was running at the rate of 20 miles per hour. Of 18 men who were in the center of the train stealing a ride, 8 were killed and 7 injured and 3 are missing.

A TIDAL WAVE, resulting from a severe wind storm, is reported from Sabine City, Tex., Sept. 14. The wind reached a velocity of 75 miles per hour and did considerable damage. As a result of the sudden rise of water, six deaths are known to have occurred and four more are reported.

GERMAN RAILWAY accidents are becoming so frequent as to arouse severe criticism in that country. From newspaper reports it appears that during the month of July 35 trains were derailed, while there were 18 collisions and 173 other accidents, in which a total of 60 persons were killed and 154 others were injured. The report further states that carelessness on the part of the employees and officials is the cause of this large list of casualties.

BRAZILIAN RAILWAYS, says a Paris news item, are to be farmed out to an English-French-German syndicate. A provisional contract has been made between the Brazilian government and the Rothschild Freres, the Discount Bank of Berlin and the Comptoir d'Escompte of Paris. A company is to be formed to take over the administration of the Brazilian railways. The capital will be $40,000,000, half of which will be taken by the English group and one-quarter each by the French and Germans. One of the conditions is that this capital is to remain in Europe for two years; and numerous sinecure offices on the railways will be suppressed and abuses in administration reformed.

100-LB. RAILS have been adopted by the Illinois Central R. R., and Mr. J. T. Harahan, Second Vice-President, informs us that the company will in the near future begin laying these rails for a distance of four miles at Cairo bridge, and will gradually extend them as renewals are necessary between the Ohio River and Chicago on the main line. As this track has been laid with new 75-lb. rails within the past few years, there will be no necessity for renewing much of it for some little time.

THE BEZER REVOLVING SEMAPHORE SIGNAL, which was described in Engineering News of July 2, 1896, was exhibited to a party of railway officers at Kingsland, N. J., on Sept. 14 by Mr. Henry Bezer, its inventor. Among those present were Messrs. Griffith and Dalrymple, Assistant Superintendent and Chief Train Dispatcher of the Delaware, Lackawanna & Western R. R., and Messrs. H. F. Baldwin and T. H. Pindell, Engineer of Maintenance of Way and Superintendent of the Erie Ry.

THE WRECKS "AILSA" AND "ALVENA," sunk respectively off Fort Hamilton and Sandy Hook, are being removed by dynamite by order of the U. S. government. The Merritt & Chapman Wrecking Co. is doing the work for $12,000 for the "Ailsa" and $25,000 for the "Alvena." Whatever is worth saving in the hulls will belong to the government. These ships are being broken up by dynamite fastened in position by divers. The "Ailsa," lying in 40 to 50 ft. of water, has already been cut into five sections, and these again have been reduced to smaller sections, which are being picked up by the 260-ton derrick. The "Alvena" lies in deeper water and the hull has been partly cut by blasting, but she will not be entirely removed before the first of next year. Storms and strong currents interfere with the work on both steamers.

A VISIT TO A NEW SEWAGE FARM AT BERLIN.

By Allen Hazen.*

In October, 1896, I had the pleasure of visiting an addition to the sewage fields of Berlin, in course of preparation, in company with Oberingenieur Adams, of the City Sewer Department, and Stadtbaumeister Meier. The general plan of the Berlin sewage farms has been so often presented that I shall not attempt to again cover the ground, but only to describe a few photographs which I was kindly allowed to take, with brief comments in regard to them. I will only say in regard to the general system that all of the sewage at Berlin is treated by applying it to land, over 10,000 acres being under actual irrigation, while the area is being extended from time to time to keep up with the rapidly increasing population.

The sewage farm which we visited on this bright autumn morning was reached by carriage from the railway station of Neu Babelsburg, perhaps 20 miles southwest from the city. The land there is very slightly rolling and quite sandy, except along the streams where the meadows are perfectly flat and inclined to be swampy. A large part of the ground is naturally covered with an open growth of tall, straight trees, belonging to the pine family. The trees are so few and the foliage is so scanty that sunlight penetrates rather freely, and the ground is usually covered with a moderately good turf. Other areas are cultivated or used for pasture, but, as a rule, the soil is too poor to be profitably used in agriculture. The material of the soil itself, both in this and in other sewage farms, is remarkably uniform, and consists of a light brown sand having an effective size of 0.13 mm., and a uniformity coefficient of 2.5 mm.* In Fig. 1 is shown a mechanical analysis representing the average of numerous samples obtained at different times from the various sewage farms.

Where the surface of the ground is covered with sod there is a little soil, but the soil layer is remarkably shallow and differs but little from the sand below it; so little, in fact, that it has been found unnecessary to keep it separate in grading, and cuts and fills are made without any regard to the material. This is, of course, possible on account of the remarkable uniformity of the material; under other conditions it would be impossible.

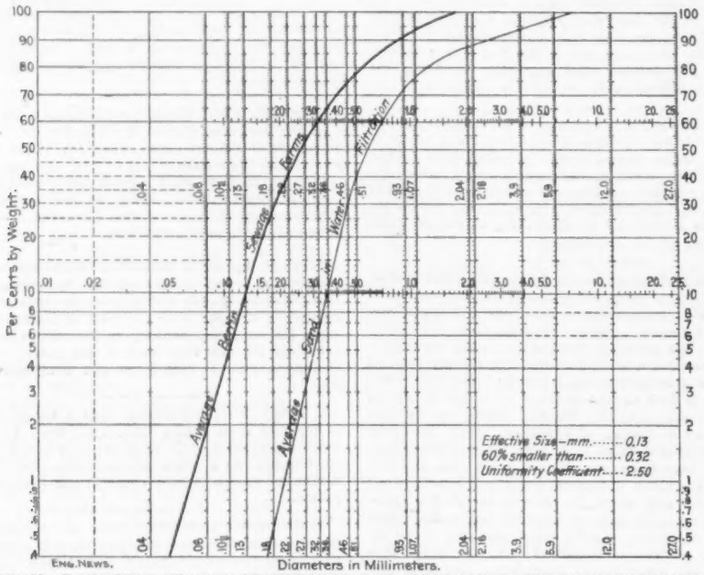


FIG. 1.—DIAGRAM SHOWING RESULTS OF MECHANICAL ANALYSES OF FILTERING MATERIALS FROM THE BERLIN SEWAGE FARMS.

In preparing the ground for use in sewage irrigation it is first cleared of the timber and stumps, where it has not already been cleared for other purposes, and is afterwards graded into level beds surrounded by low embankments, the beds being, as a rule, nearly square and less than an acre in area. Some of the beds are graded to slopes, but in this case the method of irrigation is entirely different. The grading is done with light iron dump cars running on narrow gage tracks, as shown in Fig. 2. The material is shoveled into these cars by laborers. Roots, etc., are thrown back onto the area graded, and are afterwards collected and burned. The cuts and fills very rarely exceed 2 or 3 ft. The tramway track is so light that it can be picked up and moved, without taking apart, by men standing along its line.

After the grading is finished, the underdrains are laid. The drains are rather shallow and quite near together. The material in the ditches stands up perfectly, and by the use of special spades, having blades only 4 or 5 ins. wide, men selected for their small size are able to dig a ditch not more than 12 ins. wide at the top and 8 ins. wide at the bottom at a cost of less than 1 ct. per lin. ft., the ditch being from 4 to 6 ft. deep, according to circumstances. One of these ditches is shown by Fig. 3, which also shows in the background the original pine forest. This is for one of the lateral drains from 2 to 3 ins. in diameter. The main, or collecting drains, from 4 to 6 or 7 ins. in diameter, are usually laid somewhat deeper and the ditches are also wider, with a corresponding increase in cost. One of these main drains is well shown by Fig. 4, which also shows in the distance some of the stacked-up crops grown in the fields below, which are already under cultivation. The lateral drains are not more than 30 ft. apart and are put down with grades as low as 1 in 250. The main drains of larger size have grades as low as 1 in 500. These main drains are continued until the quantity of effluent to be provided for exceeds the capacity of the largest ordinary agricultural tile, which are 6 or 7 ins. in diameter. Beyond this point open ditches are used, as shown in Fig. 5. These ditches are excavated in the sand with slopes of 1 to 1½, and the sides are prevented from sliding down by driving stakes at intervals on the sides, and between them is placed brush and other refuse obtained from the land cleared. Willows are also planted, and the bottom is supported by driving stakes, ½ to 2 ins. in diameter, 8 ins. apart, back of which brush is placed. Poles are placed on the tops, and the two sides are held apart by frequent cross pieces, as shown in the view. These light structures hold the bank from falling or washing for a few years, after which time they can be renewed if necessary, but usually the willows and grass, whose development is aided by the sewage above and the effluent below, have obtained such a growth as to hold the banks without further care, beyond the occasional cleaning out of the channel at the bottom. This view also shows a little of the fields above the banks, while the depth of the ditch can be judged from the height of Ingenieur Adams, who stands at the bottom. The details of this brush-work are better shown by a view of another ditch more recently constructed, shown by Fig. 6.

The distribution of the raw sewage is effected by a system of iron pipes, in which a sufficient pressure is maintained to allow sewage to be drawn freely from any of the outlets. To regulate the pressure in the pipe system, stand pipes are placed on summits, one of which is shown by Fig. 7. This stand-pipe is provided with an overflow which discharges onto the beds in the immediate neighborhood, and thus prevents the pressure from exceeding a certain limit. It is desired, however, to use a pressure somewhat lower than this, and this is accomplished by placing a float in the stand-pipe which carries on a long rod a box sufficiently large to allow it to be seen for a long distance. This signal goes up and down with the pressure, and the gate tenders for a long distance around can open or shut their gates accordingly, as the signal rises or falls.

Fig. 2.—Hand Cars Used in Grading Beds.

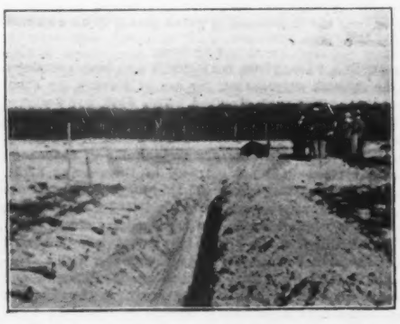


Fig. 3.—Narrow Ditch for Small Underdrain.

Fig. 5.—Open Ditch for Underdrainage or Effluent.

*St. Paul Building, New York city.

*The diameter of the sand grains at the 10% point on the curves is the effective size; the ratio between the diameters at the 60% and 10% points is the uniformly coefficient.

The outlets from the iron pipes into the earth distributing channels are extremely simple. An ordinary gate allows the sewage to flow into a slight excavation in the ground, the sides of which are protected by rough wooden sticks, hardly 2 ins. in diameter, backed by brush, as shown in Fig. 8. The little sewage distributing basin thus formed is divided by two partitions of similar construction to the outside walls, which compel the sewage to flow through it by a circuitous route before flowing into the earth carriers. Pieces of paper and other large suspended matters are deposited in these receivers, and are cleaned out from time to time and burned or otherwise disposed of. These receivers are extremely inexpensive, and there is nothing of a permanent nature about them except the iron pipe through which the sewage enters, but they seem to answer their purpose of removing the grosser matters of the sewage fairly well although there is apt to be more odor from them than from any other part of the system. They are, however, regarded as desirable after many years' experience, and are always placed at outlets.

Fig. 4.—Ditch for Main Underdrain.

After leaving this slight receiving basin the sewage flows through a system of open carriers to the various beds. These carriers are made up by simply piling up the sand, perhaps throwing into them sod, if any is available. A little care is required to keep them in shape at first, but after they are once fairly brought into use a vigorous growth of grass appears over the surface and preserves them from further change of shape. The bottoms of these carriers are always somewhat higher than the surface of the beds to be irrigated from them, so that they can be completely drained when not in use. The flow of sewage in them and from them onto the beds is controlled by wooden gates soaked in tar, as shown by Fig. 9. These gates are reasonably tight, extremely inexpensive, and readily replaced when necessary.

Fig. 7.—Stand-Pipe Regulating Pressure.

Fig. 10 shows a field under irrigation, from which a crop is just being removed by a team of four oxen hitched up abreast. There are numerous villages on the sewage farms, surrounded by the fields.

The cost of preparing land for irrigation is stated to be on an average about as follows:

	Marks per Hectare.	Dollars per acre.
Grading and embankments	400	39
Draining	400	39
Distribution system for raw sewage, including iron carriers and general expenses	500	48
Total expenses of preparing land for use	1,300	126
Average cost of land to the city..	2,000	194
Total cost of land ready for use..	3,300	320

ELECTRIC TRACTION ON THE METROPOLITAN ELEVATED R. R., CHICAGO.*

By M. H. Gerry, Jr.,† M. Inst. Elec. E.

In the following paper will be found a brief discussion of some of the more important problems arising in connection with the application of electric motive power to the heavier classes of railway service. A number of tests and diagrams from the Metropolitan Elevated Railroad of Chicago are introduced by way of illustration.

Fig. 6.—Another Effluent Ditch.

A part of this paper relates especially to the application of electric power to passenger rapid transit on elevated and suburban roads. The conditions of this service differ somewhat from common railway practice. Regular stops are made at frequent intervals; the distance between stations on elevated roads, for example, averaging about 2,000 ft. The interval between trains is small, and the time of stops very short. The traffic is irregular, is heavy at certain hours, and is apt to increase and decrease at a rapid rate. To make the fast running time desired, the speed must increase up to the point where the brakes are applied; thus the maximum speed is high compared with the mean speed, and the running time depends almost entirely upon the rate of accelerating and retarding of the train.

With a given number of stops per mile, the amount of power required will increase very rapidly with the speed beyond a certain point, and the cost per car mile will not furnish a reliable basis of comparison for the motive power of different roads unless the conditions are the same. A slight difference in the average speed, or in distance between stations, may cause a considerable change in the amount of power required.

Fig. 8.—Sewage Outlet and Screening Basin.

There are in operation at the present time several noteworthy examples of the application of electric motive power to the heavier classes of railway service. The most important of these installations are the Lake St. and the Metropolitan Elevated Roads of Chicago, the Baltimore Tunnel Line of the Baltimore & Ohio, and the Nantasket and Berlin lines of the New York, New Haven & Hartford Railroad. From the experience gained on these roads, there is no longer a question in regard to the ability of properly designed electric motors to operate trains of the heaviest weights in service, and at any speed permissible under practical railroad conditions. In the future matters of efficiency and general utility must determine the desirability of electric power for any particular railway service.

Certain operating conditions have a special bearing on the efficiency of this form of motive power; the most important being the frequency of the train service. If traffic is such that a large number of trains must be operated on a division, the electric power will have an advantage in point of economy over steam locomotives; and if the trains are few, the reverse will be the case. This condition holds good independently of the weight of the trains or of the speed attained. The length of the line is in itself no bar to the successful operation of an electric railway system, as, by using alternating current apparatus, the power stations may be located favorably, and at long distances apart.

Fig. 9.—Wooden Gate in Sewage Carrier.

The distribution of the current to the trains, while it presents many practical difficulties in detail, is not so serious a problem as it was thought to be at one time. Of the three systems of overhead conductor, conduit and third rail, the last has given the best results, and is advisable wherever the conditions are such that it can be installed. For roads operating on their own right of way, there is really no serious objections to the third rail, and all of the difficulties encountered at crossings, switches and in yards can be overcome by methods already in use on the roads named above, or by other devices that have been proposed. It is not to be expected that all details of such a system are in an entirely satisfactory and final form, but they are practically operative at present and being constantly improved as difficulties develop in service. The experience already gained also justifies the statement that a reliable overhead or conduit system for heavy service can be constructed if the conditions favor the use of such methods.

Fig. 10.—Field Under Irrigation, with Crop Being Removed.

The Metropolitan Elevated Railroad.

This system, now in its second year of operation, is the largest road in existence employing exclusively electric power for a heavy passenger service.

*A paper presented at the 14th general meeting of the American Institute of Electrical Engineers, Eliot, Me., July 26-28, 1897.

†Supt. of Motive Power, the Metropolitan West Side Elevated R. R. Co., Chicago, Ill.

The structure has four tracks, from Market St. west to Marshfield Ave., at which point three double track lines diverge. The northerly branch divides again near Robey St. into two double track branches. From Market St. to each of the terminals the distance is about six miles. (See map, Fig. 1.)

Current is conveyed to the trains by the third rail system; the "trolley rail" being placed 20⅛ ins. outside and 6¼ ins. above the running rail. It is the common "T" section, bonded with leaf copper bonds, and divided into sections to provide for expansion. The insulation for the third rail on all but a small section of the road, consists of hardwood blocks, mounted on small iron chairs fastened to the ties. On a recent extension an improved form of insulation made of stone-ware has been tried with success. The electric leakage is small at all times. In dry weather it is entirely negligible and in wet weather is never more than a few amperes. It is greatest after a dry season, when the first shower is washing the accumulated iron dust from the insulating blocks. Steel rails are used for feeder and copper only to make connections. The feeder system is divided into six sections, which are tied together at junction points through circuit breakers placed in the interlocking towers.

The rolling stock consists of motor cars, passenger cars and a few coal and flat cars. The motor cars measure 47 ft. in length and weigh about 62,000 lbs. when loaded to their maximum capacity. They are mounted on rigid bolster locomotive type trucks, having 33-in. steel tired wheels. The truck centers are 33 ft. 6 ins. apart and the truck wheel base 5 ft. 6 ins. One truck of each motor car is equipped with two motors, each nominally rated at 2,000 lbs. drawbar pull. The motors are operated by series-parallel controllers, situated in the cabs at each end of the car. Rheostats of the packed ribbon type, used in connection with the controllers, are placed underneath the

Fig. 1.—Map of Metropolitan Elevated R. R. Lines, Chicago.

car. A circuit breaker placed in each cab is used both as a safety device and as a main switch for opening the circuit between the trolley device and the controller. A main fuse box is also provided, and placed in one of the cabs as an additional safety device, but experience has shown that failures of the circuit breaker to act are so rare, that the former piece of apparatus might well be omitted. Circuit breakers have proven very satisfactory for this service, as they cost little for maintenance, are reliable as safety devices, and by their quick action reduce to a minimum the damage to apparatus from grounding and short-circuiting.

The cars are warmed by electric heaters arranged in three circuits, two of which take about seven amperes each and the remaining circuit about four amperes. All of the heaters are required only in the coldest weather, and are turned on and off by the trainmen. By cutting out all or part of the heaters for a short time when the traffic is heaviest, the peak of the load can be reduced and the heaters used to improve the load factor.

The air-brakes are of the direct or "straight" type, with an additional reinforce cylinder. The air is compressed to 60 lbs. by a vertical pump, driven by a motor of about 3 HP. The pump motors have automatic control, regulated by the air pressure and also hand control from each end of car. The pump with its motor and automatic controller is placed in one of the cabs.

The passenger cars are 47 ft. in length and of the standard pattern, in use on all elevated roads. They are mounted on swinging bolster trucks, having 30-in. wheels, and when loaded to maximum capacity weigh about 46,000 lbs. Two, three and four car trains are in service at different hours, corresponding with the traffic. About 1,200 trains are handled daily and under very close headway out of Franklin St. terminal.

The power house is supplied with water tube boilers, mechanical chain stokers, coal and ash handling machinery, forced draft, automatic oiling system and all modern

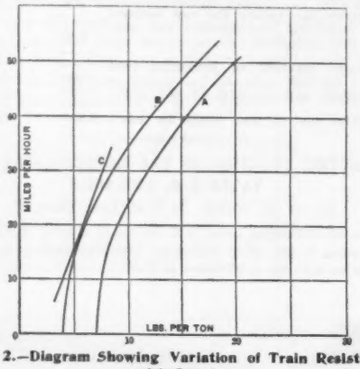


Fig. 2.—Diagram Showing Variation of Train Resistance with Speed.

A.—By Clark's formula.

B.—By formula $R = 4 + \frac{v^2}{200}$.

C.—Results of Tests on Metropolitan Elevated.

appliances. The boilers are 14 in number and work at 165 lbs. pressure. There are four vertical cross-compound engines, direct connected to the electric generators. The condensing water is taken from the Chicago River by tunnel, and water for the boilers from the city mains. There are four electric generators, two of 1,500 K-W. and two of 800 K-W. capacity. The switchboard is placed on a gallery and is provided with the usual instruments, including recording wattmeters for each generator. There are six feeder panels corresponding to the divisions of the feeder system.

The Power Absorbed by Trains.

In an electric railway system the mechanical energy supplied at the engine shaft may be divided, for purposes of discussion, into two general classes. First, that finally absorbed or utilized in propelling the train, and, secondly, the energy lost in transformation and transmission, including losses in generators, line, rheostats and motors.

The first division or class, that is, the energy to propel a railway train, may be divided again into three parts: First, that required to overcome inertia and accelerate the train to its maximum speed after each stop. Secondly, the energy required on account of ascending grades. Thirdly, that required to overcome train resistance, including friction, air resistance, etc. If the stations are far apart, the energy required to accelerate the train may be neglected without serious error, but for a service where trains make frequent stops, and the maximum speed is high compared with the mean speed, it becomes of importance and may easily be the greatest of all losses. The amount of energy required for train acceleration obviously depends upon the number of stops, the train weight and the maximum speed. Knowing these quantities, it can be readily determined from the common mechanical formula for kinetic energy, $U = \frac{w\,v^2}{64.4}$.

The horizontal effort or drawbar pull required to produce a certain acceleration in a given time may be obtained from the mechanical formula, $f = \frac{w\,v}{32.2\,t}$.

The work done in ascending grades is the product of the train weight and the vertical distance the train is lifted. The horizontal effort required to take a train up a grade is equal to the product of the train weight by the per cent. of grade.

Train resistance, as used in this paper, includes all retarding forces other than those due to inertia and grades. Formulas for determining this quantity are empirical and the based upon experimental results, where the conditions have varied widely. D. K. Clark, in "Railway Machinery," recommends a formula which, reduced to tons of 2,000 lbs., becomes $R = 7.1 + \frac{v^2}{192}$. Another formula in use is $R = 4 + \frac{v^2}{200}$, where R = resistance in pounds per ton of train weight, v = speed in miles per hour. These two formulas have been plotted in Fig. 2, and are marked respectively A and B. From measurements taken on the Metropolitan Elevated, the curve C has been determined and is used in the following discussions:

In Figs. 3 and 4 are shown actual speed curves on a time and a distance base, for a train running between stations, 2,500 ft. apart. For the purposes of discussion, consider the train weight as 100 tons and in the first case assume it to be on an ascending grade of ½%. From the curves, the speed at the time brakes are applied is 24 miles per hour, and the kinetic energy at that speed, for the train, is 3,800,000 ft. lbs. The time consumed up to the point where brakes are applied is 77 seconds, and the energy to overcome the 0.5% grade while the train is passing over the first 1,900 ft. is equal to 1,900,000 ft. lbs. The energy to overcome train resistance for the same distance is equal to 1,045,000 ft. lbs. Summed up the energy would be as follows:

For accelerating the train	3,800,000 ft. lbs.
For the grade	1,900,000 " "
For train resistance	1,045,000 " "
Total energy required	6,745,000 " "

This represents the total energy that must be supplied to the train from the time of starting, up to the moment the brakes are applied. From this point the acceleration is negative, and the kinetic energy of the train is absorbed by train resistance, the grade and the brakes. The amount taken up by the brakes is 2,900,000 ft. lbs.

The above case is for the train on a 0.5% ascending grade. For the train on a level the figures would be as follows:

For accelerating the train	3,800,000 ft. lbs.
For train resistance	1,045,000 " "
Total energy required	4,845,000 " "

The amount absorbed by the brakes in this case will be 3,500,000 ft. lbs.

For the same train and speed conditions for a 0.5% descending grade, the figures are:

For accelerating the train	3,800,000 ft. lbs.
For train resistance	1,045,000 " "
Total energy required	4,845,000 " "
Supplied by descending grade	1,900,000 " "
Total external energy required	2,945,000 " "

The total energy absorbed by the brakes in stopping the train in this case is equal to 4,100,000 ft. lbs.

The foot pounds per ton mile in each of the cases cited are as follows:

On a descending grade	142,000 ft. lbs.
On a level	102,000 " "
On descending grade	62,000 " "

The average speed taken from the curves in the cases cited is 16.5 miles per hour, not including stops. Allowing twelve seconds for a stop, it is 15 miles per hour.

The average rate of using energy or the power, allowing time for stops, is as follows:

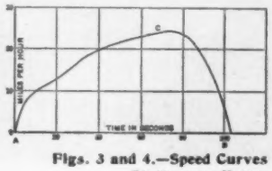
On a 0.5% ascending grade	106.5 HP.
On a level	76.5 "
On a 0.5% descending grade	46.5 "

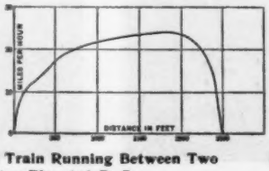
The power may also be divided as follows:

For accelerating the train	60 HP.
For ascending grade	30 "
For train resistance	16.5"

These figures do not, of course, include losses in applying the power, and only represent the energy which must be applied at the rails to produce the results in the special cases named above. The conditions vary widely at times on the same road, but the above examples may serve to show how great is the percentage of power required to accelerate the trains when the stops are frequent.

In a speed curve with a time base, such as Fig. 3, the area enclosed is proportional to the distance traveled. That part of the area enclosed by the curve from B to C,





Figs. 3 and 4.—Speed Curves of Train Running Between Two Stations on Metropolitan Elevated R. R.

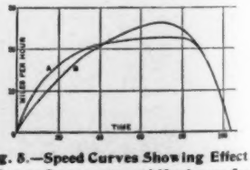


Fig. 5.—Speed Curves Showing Effect on Power Consumption of Maximum Speed Reached Between Stations.

a perpendicular from the point C, and the base line, depends on the form of the braking curve and hence on the efficiency of the brakes. The area enclosed by the curve from A to C, the perpendicular and the base line, depends on the form of the acceleration curve. The distance between stations being fixed, the area enclosed must be constant and independent of the form of the curves. The shape of the curve may be altered, however, in two general ways, first, by changing its form so as to still enclose the same area, with the same length of base, and secondly, by altering the form of the curve and changing the length

of the base. This latter change will alter the time between stations, while either of the changes may or may not affect the amount of power used, this depending principally on the maximum speed attained. In Fig. 5, the curves A and B represent equal distances passed over in equal times, but the energy required for a curve A is materially less than for curve B. The amount of power required in any case will depend largely upon the form of the speed curve, that is, upon the rates of accelerating and retarding of the train, and it is always desirable to keep the maximum speed as low as possible. Motors efficient at high speed are sometimes wasteful of energy because of insufficient torque, at starting and at low speeds, to produce a good form of acceleration curve.

The train weight may be considered as made up of two parts, the live, or paying load, and the dead load, which includes the weight of rolling stock, motors, etc. As the amount of power required by the train varies almost directly as the weight, it is desirable to have the non-paying or dead load as small as possible. In order that there may be sufficient traction, a separate locomotive must

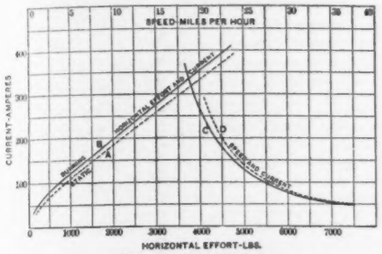


Fig. 6.—At 500 Volts.

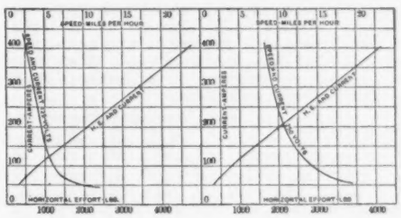


Fig. 8.—At 125 Volts. Fgi. 7.—At 250 Volts.

CURVES SHOWING RELATION BETWEEN CURRENT FLOW AND HORIZONTAL PULL OF STANDARD MOTORS, METROPOLITAN ELEVATED R. R.

weigh between four and five times the maximum drawbar pull required by the train, all of which is dead load, in addition to that of the cars. It has been stated that a rapid acceleration is desirable if there are many stops, but as each pound of increased maximum drawbar pull from a locomotive must add four or five pounds to the dead weight of the train, a point is soon reached where no further advantage is obtained by increasing weight on the drivers and drawbar pull. The weight admissible on the locomotive driving wheels, on account of track and structure, also limits the amount of traction, hence the drawbar pull and rate of train acceleration. Thus, for a service combining high-speed and many stops, there are advantages in a form of motor which may be so placed as to utilize a part of the car weight and live load, for purposes of traction. The cars should weigh as little as possible so as to reduce the total dead weight of the train, for it is well known that the ton-miles of paying load form only a small percentage of the total ton-miles moved. On elevated roads it is probably below 6% on the average and on some roads below 1%.

It is hoped that these remarks may direct attention to the question of economy in the use of power or to what may be called train efficiency, in contradistinction from the efficiency of the apparatus used in the generation and transmission of the power to the car axles. This latter subject will now be considered.

The Motors and Controlling Apparatus.

At the present time, direct-current series motors with series-parallel controllers are in all but universal use for electric railways. Shunt motors are in service in Europe to a limited extent, and alterating current motors have been given a trial. The latter have advantages under certain conditions for lines of considerable length where there are but few stops. Alternating current motors tend to run at a nearly constant speed, approaching synchronism, and do not regulate with the same facility and efficiency as direct current motors. They develop, however, a good starting torque and may even produce a better form of torque-speed curve than the common series motors. The double conductor required with alternating current motors is an objection, but there are many advantages in their favor; the system is untried and its possibilities are not fully known.

The characteristics of the motors in use on the Metropolitan Elevated are introduced in this paper rather than a general discussion, and it is hoped that this will be acceptable. By modifying the design, the relations existing between the torque, speed, current and voltage, may be varied within wide limits, but the general relations are always the same and are well illustrated by the diagrams below. All modern railway motors are much alike, the designers having been forced by the conditions imposed upon them, into practically one general type of machine. The requirements are a large output, ability to withstand heavy overloads, freedom from sparking, a low rotative speed, light weight and limited space. The result is the cast-steel multipolar motor, operating with nearly saturated fields and high magnetic densities in the armature.

In electric motors, the relations between speed, horizontal effort (or torque), current, voltage and efficiency are all fixed, and may be readily determined for any particular motor. For most practical purposes it is best to represent these relations graphically. At A, in Fig. 6, the relation between current flowing and the static horizontal effort produced, is shown for the standard motors in use on the Metropolitan Elevated Road. Curve B, in the same figure, represents the horizontal effort produced when the motor is running with 500 volts at the terminals and at the speeds shown by C. The horizontal distance between A and B represents the loss in horizontal effort due to friction and core losses. Curve D, in the same figure, gives the speeds which the motor would attain under the conditions named if there were no internal resistance, and the horizontal distance between the latter curve and C represents the loss in speed due to such resistance. Thus, the losses in a series motor may be divided into two classes, those that lessen the torque, and those that reduce the speed. In Figs. 7 and 8, the relations between current, speed, and horizontal effort, are plotted for the same motor at 250 and 125 volts. The static horizontal effort is the same in all cases, but the running horizontal effort is slightly greater for the same current at the lower voltages because the losses which affect it are less at the lower speed. At the same time the percentage of loss due to internal resistance becomes greater, as it depends upon the current flowing, while the total input of energy varies with the electrical pressure as well; hence, the reduced efficiency at the lower voltages. Curves of efficiency, in relation to the current, are plotted in Fig. 9, for the same voltages. In Fig. 10, the efficiency is plotted to the speed, and it will be seen that the curves fall off rapidly above or below a certain narrow range of speed over which the efficiency is high, at any one voltage. There is a considerable range of current and horizontal effort, over which the efficiency is high, as can be seen from Fig. 9, but it corresponds to only a small speed variation. The relations of speed to horizontal effort are given in Fig. 11. The maximum working range of the motor is from 350 to 4,000 lbs. horizontal effort, and the total speed variation on this range at 500 volts will be about 14 miles, and at 250 volts about 10 miles. The range of speed obtained in service at any one voltage is practically about one-half this amount, and if 250 and 500 volts be considered as the pressures at the motor, in series and parallel combination, then the total range of speed, without further alteration of the voltage by resistance in circuit, will be about 12 miles over a total speed range of 34 miles. For each combination of motors in series parallel, there is a certain range of speed, over which the efficiency is equal to that of the motors; but at all other speeds, resistance must be introduced in circuit, and the efficiency is reduced.

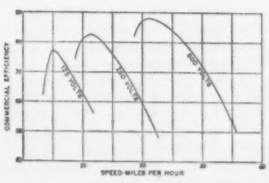


Fig. 10.—Variations of Efficiency with Current at Various Speeds and Potentials.

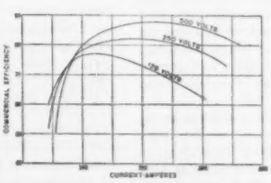


Fig. 9.—Variations of Efficiency with Various Currents and Potentials.

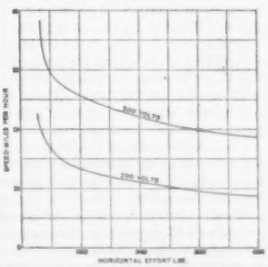


Fig. 11.—Variations of Horizontal Pull with Various Speeds and Potentials.

The weight of the armature and other revolving parts is a feature of importance in motors designed for a high-speed service, requiring frequent stops. These parts should be as light, and the rotative speed as low as possible. The armatures of the Metropolitan motors weigh approximately 1,400 lbs., and are 18½ ins. in diameter. At 800 revolutions per minute, corresponding to 25 miles per hour, the kinetic energy in each armature is equal to 43,000 ft.-lbs. Thus, for a two-motor equipment, 86,000 ft.-lbs. of energy are dissipated each time the car is stopped from a speed of 25 miles per hour. This amount of energy will vary with the square of the maximum speed and if stops are frequent, it becomes an appreciable loss.

The average load a motor is capable of sustaining is fixed by the permissible increase in temperature. The amount of such increase will depend on the average load, the efficiency of the motor and the extent and character of the heat radiating surfaces. The actual load on a railway motor differs at times, very widely, from the average load, and the ability to withstand these fluctuations will depend in part on the heat storage capacity of the motor. The metal acts to a considerable extent as a reserve of heat, receiving it when the motor is doing its heaviest work and giving it up at lighter loads. A glance at the load diagrams in the latter part of this paper will serve to show how great these fluctuations may be under certain conditions. The amount of heat radiated in a given time varies greatly with the speed of the car, and the temperatures. With the air at 60° F., and under average working conditions, a Metropolitan motor will radiate heat at the rate of about 650 British heat-units per minute. This is equal to 15 HP., corresponding about to 60 HP. of loading. But these motors will readily withstand for a considerable period of time a load of three times this amount. Most of the heat produced by this additional loading must be stored in the metal of the armature and frame. A considerable part of the heat is generated in the armature, but its thermal capacity being nearly 150 h. u. per degree, a large amount of heat energy can be stored before the temperature reaches the danger point. Slow-speed armatures in general have more metal in them, and are thus better able to stand a variable load.

The speed of a series railway motor at any given impressed E. M. F. is fixed by the total resistance of the train. The horizontal effort developed must just equal the resistance, or the velocity will change; therefore, if it be desired to maintain a constant speed, or to vary the velocity in any manner not corresponding to the fixed relations of speed and torque for the particular motor and voltage, it will be necessary to alter the impressed E. M. F., or to commutate the fields. To obtain this variable E. M. F. at the motor terminals from the constant E. M. F. of the line, many arrangements have been proposed, but only two are in use to any extent. They are by rheostat in the main circuit, and by grouping two or more motors in series and parallel combinations. Practically the two methods are combined, and are now in nearly general use. The rheostatic method wastes the energy represented by the deduction in voltage, and the series-parallel arrangement provides two or more voltages at the motors without preliminary loss. The controllers in use on the Metropolitan are two combination series-parallel and have three steps on the rheostat for each voltage. The losses in this apparatus vary from 10 to 20%, depending upon the skill with which it is handled. With care this can be kept down to 10%, making no allowance for the reduced efficiency of the motors at the lower voltages. The series-parallel system has decided advantages over all other methods thus far tried in practice, but it lacks flexibility and ultimately may not prove to be the best for heavy railway work and especially for high speed service.

The selection of the proper motors and controlling apparatus for a given service deserves more attention than it has generally received. The horse-power and maximum speed have too often been the determining quantities. A rating based on horse-power is now understood to be of little value, and the maximum speed of which a motor is capable may be of still less account as representing its performance with a train. Quite generally, motors have been speeded too high, the result being insufficient starting torque, a poor commercial efficiency and less average speed than a better selected motor would have developed.

The Generators and Feeder.

Anything like a complete discussion of modern railway generators or of the problems connected with railway feeders, might well be the subject of a separate paper. It is designed here simply to touch upon a few points relating to the general system.

Railway generators at the present time are nearly all of a direct current type, but there is reason to believe that in the future two and three-phase alternating current machines will be installed. The development of the rotary transformer will be largely responsible for this change in practice. Power stations can be more favorably

located in respect to fuel and water supply, and through sub-stations furnish power to larger areas. With this change will come also greater economy in the production of power, which cannot but have a favorable effect on the development of the electric railway.

The commercial efficiency of railway generators varies from 90 to 95%. Under favorable conditions the average or "all day" loss for large direct connected machinery (units of over 600 K.-W.) is about 7%. Direct connected alternating current generators give about the same efficiency as direct current generators. Commercially, the best results are obtained with a few units of large size. It is unnecessary and poor practice to install many small units for railway work.

The load line of an electric railway is subject to two kinds of fluctuations; first, those sudden changes caused by the starting together of a number of trains, and secondly, the more gradual change due to the variation of

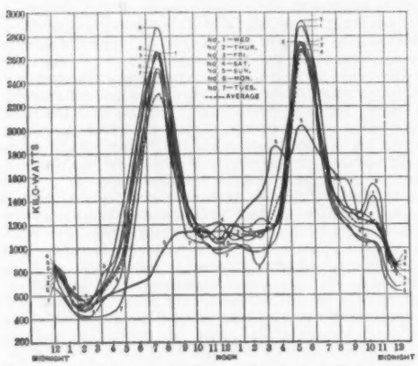


Fig. 12.—Load Curves in Power Station of Metropolitan Elevated R. R. for One Week.

traffic at different hours of the day. On roads operating but few cars, the fluctuations due to the first cause are of considerable amount, but on large systems with many cars the changes in loading from starting up of trains are very slight—hardly noticeable, in fact—and this is especially the case if the feeders are tied together and form a network. There still exists, however, the change in the load line corresponding to the traffic. A railway load line differs from that of a lighting station in having two nearly equal "peaks" or points of maxima, one in the morning and one in the evening. These variations are best taken care of by cutting in and out units, while the momentary changes can usually be cared for by a slight overloading of the machinery. Engines and generators for railway purposes have a good efficiency over quite a wide range and generally stand overloads very well. In Fig. 12 are shown seven load curves from the power station of the Metropolitan Elevated. The curves correspond to the days of the week and indicate the average power taken, but do not show momentary fluctuations, caused by the movement of trains. The chief characteristics of these curves are the two decided "peaks" occurring daily and with great regularity. The peaks vary as to amount and time with the season of the year and to some extent with the weather, but are always present in a marked degree. Street railway systems with many lines extending to different parts of a city usually show a station load with less decided and broader peaks. This is due in part to the habits and occupations by the patrons of the various lines which determine the hours of maximum traffic. When combined the load curves from a number of such lines will give a more favorable station load than any one line or group of lines in the same section of a city.

The load curves of the Metropolitan have proven to be a very sensitive index of the traffic. A delay on the competing cable lines or increase of travel from any cause is at once noticeable in the power house. The greater station loading is due not so much to the increased weight in passengers carried, as to the longer stops necessary to discharge and to take on passengers, thus requiring a higher speed to keep the trains on time.

The feeder system has an effect upon the form of load curves as well as upon the total amount of energy required. The highest percentage of loss will occur at the moment of greatest loading, but this rarely takes place at the same time on different sections, and an advantage is obtained by connecting the lines together to form a net work as far as possible. Feeders are usually divided into sections as a matter of safety and convenience. The best economy of copper and power, and the most favorable load lines are obtained when the number of such sections are as few as consistent with the safety and flexibility of the system. When feeder sections are connected the best practice calls for a fuse or circuit breaker in this circuit. The permissible percentage of loss between the power house and the trains is partly a commercial question, depending on the cost of power, and interest on the feeder investment. Transformers, rotary converters, boosters, batteries, and similar apparatus forming a part of the feeder system, should be considered with special reference to cost, operating expense, all day efficiency and effect on the load factor of the generating station.

The Efficiency of Transmission.

The energy dissipated between the engine and the car axles may be divided into three parts, that lost in the electrical generators, the losses in the transmission lines (including transformers, rotaries, etc.) and the losses in the car controlling apparatus and motors.

The amount of loss in the generators will depend upon their efficiency and average loading. Modern railway generators have good efficiency above half load, and in stations designed with reference to the load line, there is very little difficulty in keeping the machinery above three-quarters at all times. In the table below are given the efficiencies for a number of direct connected machines of modern design.

Type of machine.	Commercial efficiency, %. Full load.	¾ load.	½ load.	¼ load.
D. C. generator, 700 K.-W.	94	93	92	..
D. C. generator, 750 K.-W.	93.5	92.5	91	85
D. C. generator, 800 K.-W.	96	95	92	..
D. C. generator, 1,500 K.-W.	94.5	94	93	..
A. C. generator, 750 K.-W.	94	93	91	..
A. C. generator, 600 K.-W.	93.5	92	87	82
A. C. generator, 700 K.-W.	94	92	90	83
A. C. generator, 650 K.-W.	93.5	91.5	89.5	..
Rotary transformer, 650 K.-W.	94	92	90	..
Rotary transformer, 600 K.-W.	95.5	92.5	90	84

With machines of this type and size, the all day efficiency ought to be about 92%. A substation provided with rotaries and static transformers working under a good average loading, should have an efficiency of about 89%; a loss of 8% in the rotaries and 3% in the transformers. The substation apparatus is at its highest efficiency at the time of greatest loading, when the feeder lines are at the lowest efficiency and thus have a favorable effect on the load line.

The losses on railway feeders vary from 10 to 25%. Often there is sufficient copper if rightly distributed and tied together to reduce this at least one-half. Such a change would also improve the load factor and increase the efficiency of the station. The losses in the motors and car apparatus have already been referred to in this paper, but actual data and tests are here introduced in evidence.

From a large number of tests made on trains of the Metropolitan Elevated Road, those given in the accompanying table have been selected as illustrating this part of the subject. The trips are numbered from 1 to 8, and in the table the data for each trip are given, together with the general results obtained. All of these runs were made on a dry track, in moderate weather and under average working conditions. The total electrical energy at the train was measured by Thomson recording wattmeters and the voltage and current by Weston instruments. The velocity record was taken from a Boyer speed recorder and the stops and average speed from a double set of stop-watches. The pressure at the station was measured by a recording voltmeter.

Trip No. 1 was made from Franklin St. over the Logan Square line with a four-car train, heavily loaded, making an average running time of 13.27 miles per hour. The maximum grade on this line, going west, is 0.75% ascending for about 2,350 ft., and descending for about 1,950 ft. Other grades do not exceed 0.03% and only extend short distances. Current and speed diagrams on a time basis are plotted in Fig. 13 for trip No. 1. The current is the total amount taken by the train for power, and an inspection of the diagram will readily show the point of passing from series to multiple. The amount of energy required or absorbed by the train is as follows:

Total energy for accelerating the train	30,940,000 ft. lbs.
Total energy for train resistance	14,110,000 " "
Total energy for grade	3,400,000 " "
Total energy required for propelling the train	48,450,000 " "
Per cent. of energy for accelerating	63.9
Per cent. of energy for train resistance	29.1
Per cent. of energy for grade	7.0
Time of trip, including stops	28 min. 26 sec.
Average HP. required for propelling train	51.5
Average amperes of current	138.25
Average volts at train	504

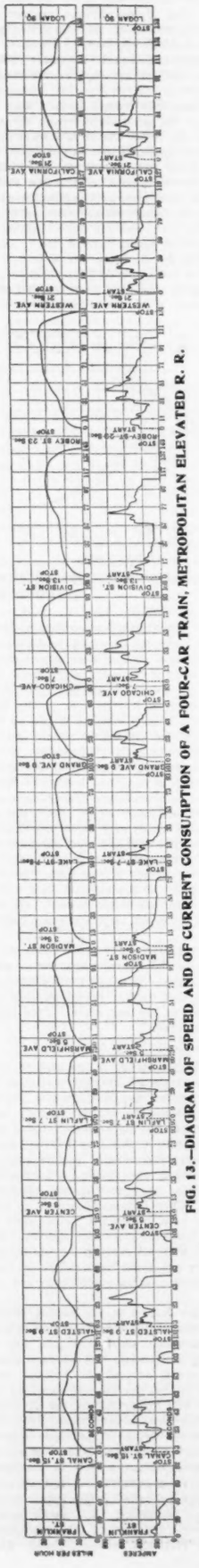


FIG. 13.—DIAGRAM OF SPEED AND OF CURRENT CONSUMPTION OF A FOUR-CAR TRAIN, METROPOLITAN ELEVATED R. R.

FIG. 14.—DIAGRAM OF CURRENT CONSUMPTION OF A TWO-CAR TRAIN, METROPOLITAN ELEVATED R. R.

Table Showing Efficiency of Electric Traction on Metropolitan Elevated R. R., Chicago.

No. of trip	1	2	3	4	5	6	7	8
No. of cars in train	4	4	4	3	3	2	2	4
Total time of trip, mins. and secs.	28—26	29—03	28—30	28—37	27—26	25—30	23—48	32—44
Total time of stops, mins. and secs.	2—19	2—05	2—42	1—47	1—16	0—54	1—22	1—41
Time running, mins. and secs	26—07	26—58	25—58	26—50	26—10	24—36	22—26	31—03
Average speed (including stops), miles per hour.	13.3	13.0	13.2	13.88	14.4	14.9	15.9	11.53
Average speed (not including stops), miles per h.	14.4	14.0	14.5	14.7	15.1	15.3	16.8	12.2
Average current (including stops), amperes.	138.3	142.6	138.6	130.2	129.5	90.1	106.6	101.1
Average current (not including stops), amperes.	148.7	153.2	151.8	137.4	135.6	92.5	112.4	106.4
Average volts (at the train), amperes	504	498	503	512	516	521	529	509
Efficiency from generators to car axle, %.	51	50.5	52	50	51	51.5	50	47.5
Kilowatt hours per car mile (at the train)	1.32	1.30	1.32	1.60	1.62	1.58	1.76	1.11
Kilowatt hours per car mile (at the station).	1.44	1.52	1.44	1.81	1.68	1.67	1.69	1.21

Average watts at train..... 69,678	
Electrical HP. transmitted to the train.....	93.4
Average volts at the station.....	545
Average watts at the station.... 75,346	
Electrical HP. at the station.....	101
Efficiency from electrical generators to car axles..	51%

Assuming the commercial efficiency of the generators as 93%, the total power required at the engine shaft to propel this train is 108.5 HP.

Trip No. 2 was made with a four-car train, under similar conditions to trip No. 1. In all of the current curves it is easy to distinguish by inspection when the motors are in series and when in multiple. The stops on the controlled are also distinguishable by the greater peaks on the curves. The smaller peaks and other irregularities are due, principally, to changes in voltage, caused by other trains in the same section, taking more or less current.

Trip No. 3 was made under similar conditions to trips 1 and 2, and the data and results are given in the table. Trips Nos. 4 and 5 were made with heavily loaded three-car trains and the results are set forth in the table. Both the speed and the commercial efficiency of apparatus are higher than in the case of the four-car trains.

Trips Nos. 6 and 7 are with two-car trains and show a higher speed than attained in the case of the three and four-car trains. The greater amount of power consumed in trip 7 is due, mainly, to the increased speed over trip 6. A current curve for the latter trip is shown in Fig. 14.

Trip No. 8 was made with four loaded cars and the motors operating only in series. Both the speed and current are less than for similar trips with the motors operating in series and multiple. The percentage of power saved is greater than that of the reduction in speed, but this is due, not to the better efficiency of the apparatus at lower speeds, but to the fact that the amount of power required to propel a train making many stops, decreases more rapidly than the average speed.

The amount of power lost in the machinery and line, as indicated by the commercial efficiency of the apparatus given in the table, might seem at first thought to be large, but considering the transformation and the distance of transmission, it is certainly not excessive. The loss in this respect is offset by the smaller cost of producing energy by power-house methods. The train weight also may be reduced with electric power to a point impossible with steam locomotives, and the rate of acceleration increased, and thus a saving effected in power used at the train. While this does not improve the efficiency of the transmission, it reduces the total amount of power required, and as a feature of the system, it should be given due credit.

Electrical energy can be produced in the vicinity of Chicago, with cheap coal, under the conditions of a railroad load, at less than ½ ct. per K-W.-hour, and in the form of mechanical energy at the car axles, costing about 1 ct. per K-W.-hour, it is several per cent. cheaper than it can be generated by steam locomotives. Add to this the actual saving in energy from a more rapid acceleration and from reduced train weight and the total direct advantage for the electrical system is obtained as far as economy in power is concerned.

While any reduction in the cost of power (not only for fuel, but repairs, labor, water, oil and waste, etc.), is of great importance to railroads, the many other advantages of electricity, representing betterments of the service and greater earning capacity are the chief qualities which will determine its adoption in any case in place of steam locomotives. As a motive power electricity is simple, efficient and wonderfully flexible, and it is hardly wise to predict its limitations.

FALL OF A PASSENGER ELEVATOR IN NEW YORK CITY.

The most serious accident to a passenger elevator that has happened in New York city in many years, occurred in the evening of Sept. 10, in the 22-story building of the American Tract Society, at the corner of Nassau and Spruce Sts., causing the death of the elevator boy and of the night engineer, who were the only persons in the car at the time. The cause of the accident has not yet been satisfactorily explained, and it is now being investigated in the Coroner's office. The building is the same one in which an elevator accident, fortunately not a fatal one, took place on Nov. 14 last, as was briefly described in our issue of Nov. 19, and discussed at length, editorially and in correspondence from elevator builders, in our issues of Nov. 26 and Dec. 3.

When the accident happened last year, a high pressure system of hydraulic machinery, the pressure being about 900 lbs. per sq. in., was in use. A bolt in the cover of a check valve broke, allowing the water to escape from the cylinder at such a rate as to cause the elevator to descend more rapidly than its normal speed, but not fast enough to cause the governor to throw in the safety clutches. There being no means provided by which the safety clutches could be operated by hand from within the car, the speed of the descending car was beyond the control of the operator, and the car struck the buffer stops at the bottom, rebounding several feet, and severely injuring one of the ten passengers. After the accident the owners of the building, desiring to take every means possible to avoid the occurrence of accidents in the future, and to satisfy the tenants of the building that the elevators were absoluely safe, called in a board of expert engineers, and, acting on their advice, had the high pressure system taken out, and an entirely new plant of machinery, working at a pressure of 250 lbs. per sq. in., substituted for it by the Crane Elevator Co., of Chicago. The original cars with the safety grips attached, made by the Otis Elevator Co., of New York city, were retained, but an additional attachment was made to the safety apparatus in the shape of a rope passing through the bar, by means of which the safety grips might be thrown in by the operator, as well as by the action of the governor.

As the two occupants of the car when the accident took place on Sept. 10 were both killed, it is impossible to obtain by direct testimony a true history of what happened immediately preceding the fall. It appears, however, from statements made by the superintendent of the building and by one of the watchmen, that on the last up-trip of the car it was stopped between the first and second floors by the safety clutches being thrown in, whether through the action of the governor or on account of the boy pulling the safety rope, is not known. The boy called the night engineer to his assistance, who, instead of examining to ascertain whether any part of the hydraulic machinery was out of order, proceeded to release the safety clutches. This he did by the means provided for that purpose; that is, he opened a trap-door in the floor of the car, and with a round iron bar or handspike, which he inserted in the holes on a capstan collar on the shaft underneath the car, he turned backwards this shaft, which by its forward rotation (operating a pair of screws and nuts and toggle joints), causes the safety clutches or grips to grasp the guides in the elevator shaft.

What happened immediately after releasing the safety clutch is at present a matter of uncertainty, but it appears from a statement made shortly after the accident by a scrub-woman who was on the 17th floor at the time that the car passed that floor going upwards at its ordinary speed. The car then went to the top of the shaft, or to the 19th floor, and then suddenly shot down the whole distance of over 200 ft. to the basement, breaking the car in pieces, tearing out the buffer beams, and breaking a hydraulic valve at the bottom of the shaft. The car was carried by eight wire ropes, all of which were found broken. The cause of the breaking of these ropes remains yet to be investigated.

The theory of one of the causes which, acting conjointly, may have led to the accident, is that after releasing the safety clutch, the engineer left the pin or hand-spike in the hole in the capstan collar and, resting against the side of the opening made by the trap-door in the floor of the car, so as to effectually lock the safety clutch open and prevent its being operated either by the safety rope or by the governor. Then, when something happened to the lifting ropes or to the hydraulic machinery, causing the car to descend rapidly, the safety clutches could not operate. What it was that happened to the machinery can at present only be conjectured. The Coroner's investigation is to be held in a few days, when all the facts that are known and the theories of the experts will be made public. In next week's issue we hope to be able to illustrate the machinery of the elevator and to discuss at length the probable causes of the accident.

MACHINE VS. HAND COAL MINING IN OHIO.

In his annual report for 1896, Mr. R. M. Haseltine, Chief Inspector of Mines for the State of Ohio, makes some statements relating to the comparative results of mining coal in that state by hand and by machine. From these statements the following abstract is made:

During the year 1896, 28,447 persons were employed in and about the coal mines of Ohio, with a total output of 12,912,608 tons. Of the total working force, 17,220 persons mined coal by the pick, and produced 9,544,259 tons, or an average of 554¼ tons per man per year of the run of the mine coal. The average time worked was 151 days; from which it results that each miner's daily production was 31,340 short tons. The average price paid for mining during 1896 was 56 cts. per ton; and as the average amount of fine coal is 2-7th of the output, in Ohio, the average wages paid the miner during the time the mines were operated was $1.47 per day, or $221.55 for the year of 151 working days. This is an average of $18.46 per month for 1896, as compared with $18.48 per month in 1895.

The persons engaged in machine mining numbered 4,346, and their output was 3,368,349 tons. By applying the rules in force in the Hocking Valley, which produces over 90% of the machine-mined coal, it is found that the men operating machines made an average of $3.45 per day during actual work. This is $455.40 per year, or $37.78 per month. Of the total output of machine-mined coal, 2,863,037 tons came from rooms and wide workings, and this was paid for at the rate of 30 cts. per ton; 505,252 tons came from narrow work, and for this 37 cts. per ton was paid. The machine mines worked 132 days; and with the above rates and amounts, the average wages of loaders and fillers in machine-worked mines was $1.80 per day, or $240.85 for the year of 132 days, or $20.05 per month. All of these figures relate, of course, to the mining of bituminous coal alone.

BRITISH INDUSTRIES AND AMERICAN COMPETITION.

It is rumored that the London & Northwestern Ry. Co. is in treaty for the delivery of 100,000 tons of steel rails from the United States, and considering the low prices and cheap freights that rule at present, there appears to be nothing improbable, though there is a great deal that is disquieting, in this report. Our manufacturers have lost the large rail contracts for Canadian main railways in which we appeared to possess a prescriptive right, and recently an order for 4,000 tons for this country, required by Mr. R. W. Blackwell, of 39 Victoria St., was secured by an American firm, by the right of price and promptness of delivery, the quality of course being secured by a rigid specification. Only a short time since another order for rails for an English line was also lost by our manufacturers, not to the United States, but to Germany; in this case, however, the railmakers had to lower their price more than 20s. a ton to secure the contract; here price and promptness of delivery placed our manufacturers out of competition. But it is not only in rails that the war of competition, which, from a pessimistic point of view, may gradually develop into a war of extermination, is now raging. We appear to be growing more and more dependent on American machine toolmakers; indeed, it is not an exaggeration to say that during the now vanishing period of depression in the United States, many once prosperous engineers' works must have been closed but for the never-failing support from Europe. We are dependent on the United States to build the elevators for the Central London Ry.; and we have to look to the other side of the Atlantic for the electrical plant with which the traffic is to be worked. It is notorious that we are unable properly to equip an electrically worked tramway, and that until our manufacturers take the trouble to learn how, the large and increasing contracts for this new industry must be taken by Americans. Now that so many employers of labor are suffering from enforced idleness by a ruinous strike, they may find time to learn why we, who still blindly call ourselves the leading industrial nation of the world, are content to close our eyes to what is going on around us; and to realize our dangers before it is too late to recover, at least to some extent, the undoubted pre-eminence we once enjoyed.—London "Engineering," Sept. 3.

THE COMMITTEE ON SMALL SCREW GAGES appointed by the British Association has rendered a second report, in which the interesting fact is developed that the committee, after considerable correspondence in England and America, has practically given the task of making standard British screw gages to Pratt & Whitney, of Hartford, Conn. The "Electrician" (London), says:

The Pratt & Whitney Co., of Hartford, Conn., had already begun to construct tools for these threads when the secretary of the committee wrote to them, and are giving close attention to their accurate production. The company have kindly promised to communicate with the committee as soon as the work is sufficiently advanced to allow them to make proposals for the supply of the gages, and the committee hope that exact gages will soon be obtainable from this source.

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We give up a considerable amount of space this week to a paper which describes the results obtained with electric traction on the Metropolitan Elevated R. R., of Chicago. The facts and figures which it contains are by all odds the best and most authoritative statement as to the economical results obtainable with electric traction in elevated railway service that have been made public. Further, as suburban service on steam railways is similar in many respects to elevated railway service, this article is the best guide we know of for any engineer who is charged with the work of making estimates as to the comparative cost of steam and electric traction on any roads where trains of several cars must be run and high speeds are necessary.

In a later issue we hope to discuss editorially some of the interesting facts which are brought out in Mr. Gerry's paper; but for the present we merely call our readers' attention to its value and importance.

In our issue of May 27 we commented on the decision of the U. S. Supreme Court to the effect that the Interstate Commerce Commission possesses no power to fix railway rates, and we expressed the opinion that under this interpretation of the law the Commission is practically powerless to remedy any infractions of that provision of the law which prohibits "unjust and unreasonable rates."

The Commission itself appears to take practically the same view, for in a decision recently rendered by it in the Eureka Springs case it says:

> Under the law so construed, the commission has power to say what in respect to the past was unreasonable and unjust; but as to rates complained of as unreasonable, unjust and unlawful, and so found to be in the case under consideration, the commission can make no provision or order for their reduction which the courts are required to enforce or the carriers are obliged to obey. Having, in the light of these decisions given the facts due consideration, we ascertained, found and reported the rates which would be reasonable from and to St. Louis, Springfield, and Seligman, Mo., to and from Eureka Springs, Ark., and have recommended that the carriers reduce and conform their charges to the facts so found and reported. This recommendation may impress the carriers only as may seem to accord with their own interests, since in the present state of the law, as declared by the court, common carriers have the power to establish, change and exact rates independent of the judgment of the commission.

In other words, the Commission says to the railways concerned, "We decide that the rates you are charging in this case are unreasonable; but do exactly as you please about changing them, for the highest court in the land has declared that this is your privilege."

It should not be hastily concluded from the above that the powers and the usefulness of the Interstate Commerce Commission, and the law under which it operates, are wholly lost. Investigating the reasonableness of rates is only one of the many lines of work of the Commission, and no candid observer can fail to be impressed with the fact that in the Commission's ten years of existence it has worked vast reforms in many fields of railway administration. The whole problem of the relations of the railways and the public is far better comprehended, both by railway officers and by the people themselves than it was ten years ago; and the educational work of the Commission has contributed to this in no small degree.

At the same time, it seems to us extremely unfortunate that one of the most mischievous features of the Interstate Commerce law, that prohibiting pooling, has been upheld and strengthened by the courts and by additional legislation, while the requirement that all rates shall be just and reasonable, a requirement whose theoretical justice at least, everyone must concede, has been declared unenforceable.

In our issue of March 18, 1897, we published some extracts from the decision of the U. S. Court of Appeals, for the Northern District of California, in the case of Bowers vs. Von Schmidt, for infringement of patents on hydraulic dredges. This decision is published in full in the Patent Office "Gazette" of July 13, and—what is quite unprecedented in the publication of patent decisions in that journal—is illustrated with some of the exhibits made by the litigants in the trial, including some of Mr. Bowers' original drawings, dated in the '60's. We call attention to this here, thinking that some of our readers especially interested in this matter may desire to secure a copy. We need hardly add that the "Gazette" is the official publication of the Patent Office, and copies may be obtained by addressing the Commissioner of Patents, enclosing 10 cts.

A remedy for the unseemly "line and staff" controversy in the U. S. Navy is suggested in the unanimous report of the Congressional Board, appointed last year to visit and inspect the U. S. Naval Academy. Among other recommendations for better organization, the third proposes that the four years' curriculum at the Academy should be alike for all midshipmen; so that every graduate shall enter the service under like conditions and be assigned to alternate duties on deck, in the engine-room, or in charge of the purchasing and commissary departments of the vessel. At the end of his four years' course the graduate would thus enter the ward-room as an Ensign, be trained to habits of command and associate under like circumstances with his brother officers of higher rank.

This recommendation properly recognizes the fact that in the modern navy it is quite as essential to be a good mechanical engineer and to be proficient in the duties of that office as it is to have a knowledge of navigation, gunnery, and what are now known as "the duties of the officer of the deck." The adoption of this system of education would in time abolish the separate staff corps of Steam Engineers and Paymasters, and remove forever from the Navy List the title of Engineer to which some of the older officers of the Navy seem to have such a firmly-grounded prejudice. But while the suggestion is a good one and its adoption would settle the question of class distinction between certain staff and line officers, there may be some doubt as to its practical working. The proper and efficient maintenance of a modern battleship involves many intricate problems of mechanical engineering, and the failure of any branch of the motive power, in an emergency, would be freighted with the most serious consequences. This means that every graduate must, above all else, receive a very thorough engineering education, and that he must have sufficient practical service in the engine-room of a battleship to be prepared for any emergency that may arise. Whether this expert knowledge can be gained in a four years' course at the Academy, supplemented by sporadic employment in this special field, is a doubtful question. Under present conditions, emergencies do arise which tax all the mechanical knowledge and skill acquired in long years of special and continuous duty. The suggestion of Congressman Wilson might be made effective, however, by graduating all upon equal terms, as proposed; but if a line officer, as he would then be, should show any special proficiency or leaning towards the mechanical part of his profession, there is no naval law, that we are aware of, that would prevent his practically permanent assignment to duties of that character. In this way alone could our Navy secure the experienced engineers that modern conditions demand; and as his title would be that of a line officer, there would be no room for staff and line prejudice, and the service would gain to the extent of his accumulated experience.

We know of no more excellent piece of work that the government has undertaken for some time than the proceedings now in progress to disbar from practice before the Patent Office a certain class of patent solicitors, whose methods of business have done a great deal to bring the whole patent system into ill repute with the public.

It has been well known for a long time that a considerable proportion of the firms which make a business of soliciting patents conducted their business in a manner more or less unprofessional; but within the past two or three years some of these firms have gone to such extremes that their business became little, if anything, less than outright fraud.

Under these circumstances the Department of the Interior has acted wisely in adopting rules for the registry of attorneys acting as patent solicitors and undertaking proceedings to disbar those who have been notoriously guilty of dishonorable practices in connection with their business. The new rules for the registry of the attorneys have evidently been drawn with care to avoid injustice to any honest patent solicitor; and err on the side of leniency, if at all. An excellent feature is the requirement that an applicant for registry as a patent solicitor, who is not an attorney-at-law in good standing, or who is not already in practice as a patent solicitor, may be called upon to show to the Commissioner of Patents that he has the necessary qualifications to render valuable service to his clients, and is competent to properly care for their interests in proceedings before the Patent Office.

Of course it is not to be expected that this action by the Patent Office will drive all the "sharks" out of the patent soliciting business. One of the class of solicitors who publish cheap newspapers to advertise their business already announces that he has been admitted to registry. It will still be necessary for the inventor of intelligence who has something worth patenting to exercise discrimination in choosing an attorney to prosecute his claims. On the other hand, such of the unprincipled class of solicitors as manage to continue in business will have the wholesome fear of disbarment before them to deter them from dishonesty; and the other and still larger class of solicitors, who, while not intending to be dishonest, have fallen into careless methods of doing business, will, we believe, be aroused by the present action of the Patent Office to a clearer understanding of the fact that neglect of the interests entrusted to them is a serious matter, and one for which they may be called to account.

THE CARPENTER PROCESS FOR MAKING ARMOR PLATE.

The recent offer by Mr. J. H. Carpenter, of Reading, Pa., to the Navy Department, proposing to furnish armor plate at a mill cost of $100 per ton, plus a reasonable margin for interest and profit, has given rise to much comment in the daily press and elsewhere. It appears from an interview with Mr. Carpenter, published in the Philadelphia "Manufacturer," that a new process of making steel is one of the elements upon which his proposition is based, by which process he expects to produce steel at a much lower cost than it can be

made by any of the old processes. We quote the following from the interview:

He says in regard to his discoveries that he found in Europe that one of the most important features in steel casting had been so improved upon as to overcome the greatest difficulty known in casting steel, that is the casting of solid ingots free from the usual blow holes, sponge, etc., and accomplished without the necessity of enormous sink-heads, and saving, therefore, the great waste known as toppage. Mr. Carpenter says:

"I saw a cast of six tons made from a two-ton pneumatic converter by pouring the three successive heats into a ladle and from thence into the mold which was made in green sand, that is, in a sand mold which was only partially dried, just enough to set the sand firmly. The riser weighed about 400 lbs. There were no blow holes or shrinkage cracks, the edges were square and the inequalities in thickness were all sound in their fillets. The steel was of fine dense grain and the test pieces cut out were pulled, showing 76,000 lbs. tensile strength, elastic limit—42,000 lbs., elastic limit, 32% elongation, and 42% reduction of area; inch square bars from it were bent double cold without fracture."

He concludes naturally that the quiescent condition of steel after pouring having been accomplished, and after reactions eliminated, it is easy to make laminated steel plates of different carbons and conditions, and after proving his theories he claims the scrap is no more than what he needs in the successive heats, and scrap, except in the care and cutting of it into suitable sizes is not a charge on the cost, but the cost of its care is duly charged. With reduced wastage, which now amounts to 60% of the ingot, was made by the open-hearth furnaces, the saving of the Harvey and other processes, besides the reduced cost of handling, etc., makes it feasible to provide armor plate at a mill cost of $100 per ton.

As the statements quoted above contained no intimation of the nature of the new steel process, we wrote to Mr. Carpenter asking if he could furnish us some particulars concerning it, and have received the following in reply:

Sir: I inclose a brief description of the new pneumatic process for making and casting steel, as requested, hoping it will be satisfactory.

I certainly have achieved notoriety, and I feel confident in saying if the government is in earnest in wanting its own plant, the methods of manufacture will have an influence with them. If not, they will have a bearing on the future of armor plate as made in this country and in Europe. Yours, truly, Jas. H. Carpenter.

Reading, Pa., Sept. 1, 1897.

New Methods of Steel Casting.

In Europe they are successfully using a new method of steel casting, and it is also being introduced in the United States.

It is a pneumatic process somewhat similar to the Bessemer process, in that the iron is melted in a cupola under air pressure and run from there into a similar converter. The Bessemer and other processes blow air through the molten mass to consume the graphite, and some add the churning and gyrating motions to the mass to hasten the elimination of the carbonic oxide. But the new process discards all these features and blows air only through the slags and scoria as they arise to the top of the molten bath, oxidizing them, and a second set of tuyeres lets in air under low pressure, which, mixing with the gases, causes their rapid combustion, thus generating a heat over the metal which raises it to any desired temperature, freeing the metal from latent impurities and preparing it for alloying and recarbonizing mixtures.

The shape of the converter and the placing of the tuyeres is to prevent the possibility of the least agitation being given to the metal, and no air is blown into the metal. The elimination of the slags depends upon the difference in specific gravities. The mass of metal is entirely decarbonized in 15 minutes, analysis showing but 0.030 carbon, which is but a trace.

No air having been blown into the metal, there is no occlusion of nitrogen, which, being incombustible, attaches in part to the metal, and no hydrogen from the vapor which the air contains, and therefore there is no danger of forming ammonia, which in combination with carbonic acid produces the blow holes and spongy toppings to ingots. The metal thus produced may be poured perfectly liquid with remarkable fluidity into the ordinary sand molds common to the iron foundry. The absence of the usual after reactions common to steel enables the workmen to fill out the molds perfectly, using only enough gatage to be sure of the mold being filled, and in the majority of cases the mold need only be skin dried, and the casts, whether they be ingots, billets, blanks or shapes, are perfectly sound, malleable, sharp on their edges and filled out to all inequalities in thickness without shrinkage cracks and sound in the fillets. Being interested, I spent several weeks with the inventor, visiting the several plants in France, Belgium and England, and satisfied myself fully of the uniformity of product, and by experiments proved the capability of the processes being adopted in making steel of higher grades.

The physical condition of the metal, as shown by the test pieces, showed from 65,000 to 80,000 lbs. tensile strength, 38,000 to 45,000 lbs. elastic limit, 28 to 36% elongation, and from 35 to 55% reduction of area. An inch bar was bent double when cold.

From the above description it appears that the new process is simply a modification of the Bessemer process, and it bears some similarity to the Clapp-Griffiths, the Robert, and the Bookwalter modifications of the process, which were exploited to a considerable extent some years ago, but which have now practically disappeared. We fear that Mr. Carpenter has been deceived as to the merits of the new process. Whatever advantage there may be in blowing the blast of air into the super-incumbent slag instead of directly into the molten iron, such as the prevention of the occlusion of nitrogen, hydrogen and ammonia, already appertains to the open-hearth process, and it does not seem possible that metal decarbonized in a Bessemer converter by blowing air into the slag can be any freer from gas which causes blow holes in the ingot than metal decarbonized on the bed of an open-hearth furnace by the passage over the slag of a great volume of highly heated air.

In the interview from which we have quoted above, Mr. Carpenter gives the items entering into his estimated cost of $100 per ton as follows:

Permit me to refer you to the table of costs as presented, and if any one can criticise the items, let us hear his story:

Pig iron of suitable quality	$14.00	per gross	ton.
Cost of reducing a charge	3.50	"	"
Alloys, etc	5.00	"	"
Heating and forging	15.00	"	"
Care of scrap	5.00	"	"
Steam power and fuel	15.00	"	"
Tempering	2.50	"	"
Average machining	20.00	"	"
Bending and handling	10.00	"	"
Administration	10.00	"	"
Total mill cost	$100.00	"	"

Adding 6% interest on the cost of plant, etc., at $1,000,000 would be $60,000 per annum; minimum of manufacture, 3,000 tons, would place the interest cost at $20 per gross ton, making the total $120 per gross ton; adding 25% as dividends, which will be $30, will make the grand total $150 per ton; adding 100% the total would be $240 per ton, and the price would not be unreasonable when compared with the price allowed by law.

We have no desire to criticise these items except to say that the figures appear to have a roundness about them that is not indicative of close figuring, but rather of the roughest kind of estimating, or guessing. We would point out, however, that even if the new process should avoid, as is claimed, the necessity of enormous sink-heads, and should save, therefore, the great waste known as "toppage," now amounting to 60% of the ingot, this saving is not so great as would at first appear. The 60% of the weight of the ingot which is cut off the top to insure that the remainder be solid metal, is not lost, but is melted over again, and the only loss is the cost of cutting off, labor of handling, the cost of remelting, and of the ferro-manganese used in the recarburizing. It is not likely, therefore, that the topping increases the mill cost of the ingot used for armor plate more than $10 per ton. The cost of making steel by the open-hearth process is now but little greater than that of making it by the Bessemer process, and whatever advantage the latter may have in point of cost is more than overbalanced by the greater reliability of the open-hearth in producing any required quality, and by its facility for using its own scrap. We think, therefore, that if armor plate is to be obtained by the government more cheaply in the future than it has been in the past, as is quite likely, the cheapening will not be due to the substitution of some modification of the Bessemer process for the open-hearth process, but to other causes, rather financial than metallurgical, chief of which will be a diminution of the percentage added to mill cost for wear and tear and interest on cost of plant, and a diminution of manufacturer's profits.

LETTERS TO THE EDITOR.

Methods of Compensation in Direct-Acting Pumping Engines.

Sir: In your notice of the D'Auria pumping engine in your issue of Aug. 26, there is no mention of other methods of compensating steam expansion in such engines, except what is known as the Worthington system of compressing air in the earlier portion of the stroke to supplement the expansion curve after steam is cut off.

Some of your readers given to hydraulic studies will recall the Groshon system, that of Mr. Davy, and also the application of simple weights, that represent the same functions as the circulating water does in the D'Auria engine, but with less friction and other resistances.

Prof. Albert W. Smith, of Stanford University, about two years ago made up a very clear analysis of compensating direct-acting steam pumps by inertia and momentum of masses, bearing suitable proportions to the load and velocity, and applied apparatus to demonstrate the truth of his computations.

He succeeded in producing some excellent indicator-cards, and raised the query, why are not common pumps arranged in this manner? The apparatus was a simple lever and weight that would not have added 10% to the cost of a pump, while the effect was such as to convert a wasteful full-stroke engine into a fair expanding one.

A search made among patented inventions at Washington disclosed the fact that the scheme was old, and its non-use must in charity be charged to some inherent difficulty in operating, not apparent in the experiments made by Prof. Smith.

The loss of energy by circulating water through curves amounting to 540°, and the friction in the loop pipes, must in the D'Auria engine amount to a great deal more than is encountered by a pendulous mass connected to the piston; besides, there would be saved an extra cylinder and piston and the additional length of the whole structure to accomodate these.

The Groshon system, in which the compensation is derived from a piston sustaining the discharge pressure and a linkage to distribute its force, seems to have the advantage over other devices that the compensating function is a resultant of the water and steam pressures.

My main purpose in addressing you is to suggest that a paper or contribution from some skilled engineer on the mechanical compensation of direct-acting steam pistons would form an acceptable and useful addition to our technical literature, also that in sucn an essay it would be interesting, though not wholly relevant, to include the reciprocating counterbalance weights applied by Captain John Ericsson on his first "monitor" engines.

Very respectfully. J. Richards.

22 California St., San Francisco, Cal., Sept. 2, 1897.

Concerning the Latest Members of the Civil Engineer Corps, U. S. N.

Sir: I desire to call attention to at least two of the misstatements of Mr. John Martin in Engineering News of Sept. 9, in regard to the recent appointments in the Civil Engineering Corps of the U. S. Navy.

In the first place, when Mr. Martin states that these gentlemen at the time of their appointment were holding places in the Departments at Washington "as clerks," he displays his ignorance of the work carried on in the Departments of the government. He should know that the great bulk of the work of the government is of a professional and technical character, and is performed by practical professional men—lawyers, engineers, chemists, etc. Of course there are many "clerks" also, whose functions are the same as clerks in the offices of lawyers and engineers elsewhere. The two recent appointees to the Civil Engineer Corps of the Navy were no more mere "clerks" in Washington than they are in their new positions, if indeed as much. Both were performing responsible technical work worthy of any man.

In the second place, when Mr. Martin states that neither of these men were "practical" engineers he is somewhat reckless in his charges. Had perchance Mr. Martin been a competitor in the recent examination, he would know that the previous practical experience proven by the competitors was a factor in making up the standards, and that all the competitors had to prove a certain time of practice in the profession, as well as graduation from a school of standing.

The practical experience of one of the appointees, Mr. F. T. Chambers, I know to be such that he will be a very valuable man to the Navy Department if given the opportunity. He has been employed in the office of Mr. Henry Aiken, Consulting Engineer, of Pittsburg, a prominent designer of steel plants, where he was not a "clerk," but was in charge of the structural work, according to Mr. Aiken's own statement. He has also been employed by the Pittsburg Bridge Co., leaving them to enter the Supervising Architect's Office. In this last place his work was purely professional and practical, in structural ironwork.

If Mr. Martin ever has any dealings with Civil Engineer Chambers, he will find him not only practical, but professional. Respectfully,

F. L. Averill, Assoc. M. Am. Soc. C. E.

Washington, D. C., 1479 Columbia road, Sept. 12, 1897.

Minimum Fees for Young Engineers.

Sir: In answer to the questions put by J. R. S. in the issue of Engineering News of Sept. 2, I wish to say that they should receive earnest attention from all young engineers similarly situated. I am a young engineer located under conditions similar to J. R. S., in a live Western town, whose population is rated at 11,000, and hold the offices of City Engineer, Superintendent of Sewers and County Surveyor, all of which are "fee" offices. The official duties of all these together do not amount to as much, in point of remuneration, as a private practice, because the engineer here is considered superfluous, and the economy of calling oftener upon his services in the prosecution of public affairs is not recognized. I could get more work in

surveying if I were content with laborer's wages, but, believing that "a man stamps his value upon himself," I have made it a rule, under all circumstances, to charge the full legal fee for all classes of work, for which the maximum is fixed by statute or ordinance, and in private practice never less than $5 per day of eight hours, while the higher rates of compensation are governed by the amount of responsibility involved. My minimum charge is $2 for professional services of any kind, and very frequently I do little things without compensation, as favors, rather than cheapen my services by charging small fees for things that do not require more than a few minutes either in the field or office.

Any one who has been similarly situated will know that at first there is, apparently, a considerable loss of work; but is there any real loss? As time passes the young engineer will see that he is more or less successful in stamping a value upon his professional services; and, as in my own case, I find it is easier to collect the full fee for my services than it was for my predecessors, who cheapened their services to suit their clients' wishes—barga'ned them off like so much shoddy merchandise.

The young engineer must cultivate self-esteem (not vanity or egotism), put a proper valuation upon his professional ability and must not cheapen his services, to meet the competition of incompetent engineers. My experience in the West has been that a large proportion of the competent engineer's practice consists of correcting and undoing the mistakes of incompetent engineers, and this source of income increases with a growing reputation for ability, accuracy and professional integrity.

The young engineer cannot place the value of his services on a par with those of an old and experienced engineer with an established reputation; and in fixing the price, he has a perfect right to give due consideration to the value and the advantages of experience and prestige afforded by the case in hand. Were it not for his duty to the profession at large the young engineer could well afford to undertake many projects, for a mere pittance, for the sake of the professional prestige they would win for him. Respectfully, K. C. A.

Nebraska, Sept. 5, 1897.

Erroneous Use of Euler's Formula.

Sir: Referring again to Prof. Barr's paper on "Current Practice in Engine Proportions" in your issue of July 29, 1897, and to a discussion on his use of Euler's column formulas in designing piston and connecting rods, in your issue of Aug. 19, permit me to say: 1. The footnote appended to the title of the paper stated that it was read before the Mining Engineers, and I am not a member of that society. I had no knowledge of the paper until its appearance in Engineering News, and hence had no opportunity of discussing it before the Mechanical Engineers, as suggested by Prof. Barr. 2. The formula which Prof. Barr uses for piston rods, $P = \frac{\pi^2 E I}{4 L^2}$, is not Euler's formula for any kind of end conditions. The three forms of this formula are:

For ends pivoted, or free to turn:

$$P = \frac{\pi^2 E I}{L^2} \left(\text{for } \frac{l}{r} \text{ more than about } 100 \right).$$

For one end pivoted and one free:

$$P = \frac{9}{4} \frac{\pi^2 E I}{L^2} \left(\text{for } \frac{l}{r} \text{ more than about } 150 \right).$$

For both ends fixed in direction:

$$P = \frac{4 \pi^2 E I}{L^2} \left(\text{for } \frac{l}{r} \text{ more than about } 200 \right).$$

A piston rod should be considered as fixed at one end and free to turn (slightly) at the other, for which condition the numerical co-efficient is 9-4 instead of ¼. When ¼ is used it is no longer Euler's formula at all. The danger in Prof. Barr's paper lies in his leading his reader to suppose that Euler's formulae may be used in such cases with safety. For instance, suppose it be required to find the diameter of a piston rod 40 ins. long, carrying a compressive load of 40,000 lbs., with a factor of safety of 6. Now, if we consider the piston rod as fixed in direction at one end, as it surely is by means of the packing ring, and free to turn at the other, as suggested by Prof. Barr, Euler's formula for this case gives:

$$6 P = \frac{9}{4} \frac{\pi^2 E I}{L^2} = \frac{9 \pi^2 E d^4}{4 \times 64 L^2}, \text{ whence we find } d = 1\tfrac{5}{8} \text{ ins.}$$

The area of this rod is 2 sq. ins., and hence the stress per sq. in. is 20,000 lbs. As the ultimate strength of a column is its elastic limit, which for a steel rod is about 40,000 lbs. per sq. in., we find we have in reality but a factor of safety of two instead of six as we have supposed.

J. B. Johnson.

Washington University, St. Louis, Mo., Aug. 26, 1897.

(The footnote to Prof. Barr's paper was incorrect in stating that it was read before the Mining Engineers instead of the Mechanical Engineers.—Ed.)

Large Profits from Garbage Disposal Not Possible.

Sir: We have read with much interest and profit your article of Aug. 26, entitled "Garbage as a Fuel for Electric Light Stations."

There is so much trash and nonsense written by otherwise sensible people of scientific attainments, that it is refreshing to see a journal grasp the situation as yours has done in regard to the fallacies concerning the destruction of garbage and the chimerical ideas in relation to the vast profits in handling the same.

This company has in St. Louis the most perfect, and we might say, the only perfect garbage treating plant in the world. It is a success from every point of view, including the sanitary point, except from a financial standpoint. The stockholders and directors of this company have expended about three-quarters of a million dollars in establishing and perfecting this plant, but have not yet paid one dollar of dividend to its stockholders. The reason is that the apparently real but entirely untrue claims about profits in treatment of garbage deceived the promoters and they accepted the contract from the city as a compensation, in the way of bonus, of about only one-half of what they should have received. It is the veriest nonsense to claim that there is any other but a moderate profit in the treatment of garbage. The only commercial products therefrom are grease and fertilizing material. These materials follow the market in price—up and down—and even at the best, do not yield sufficient revenue to pay the expenses of running the plant.

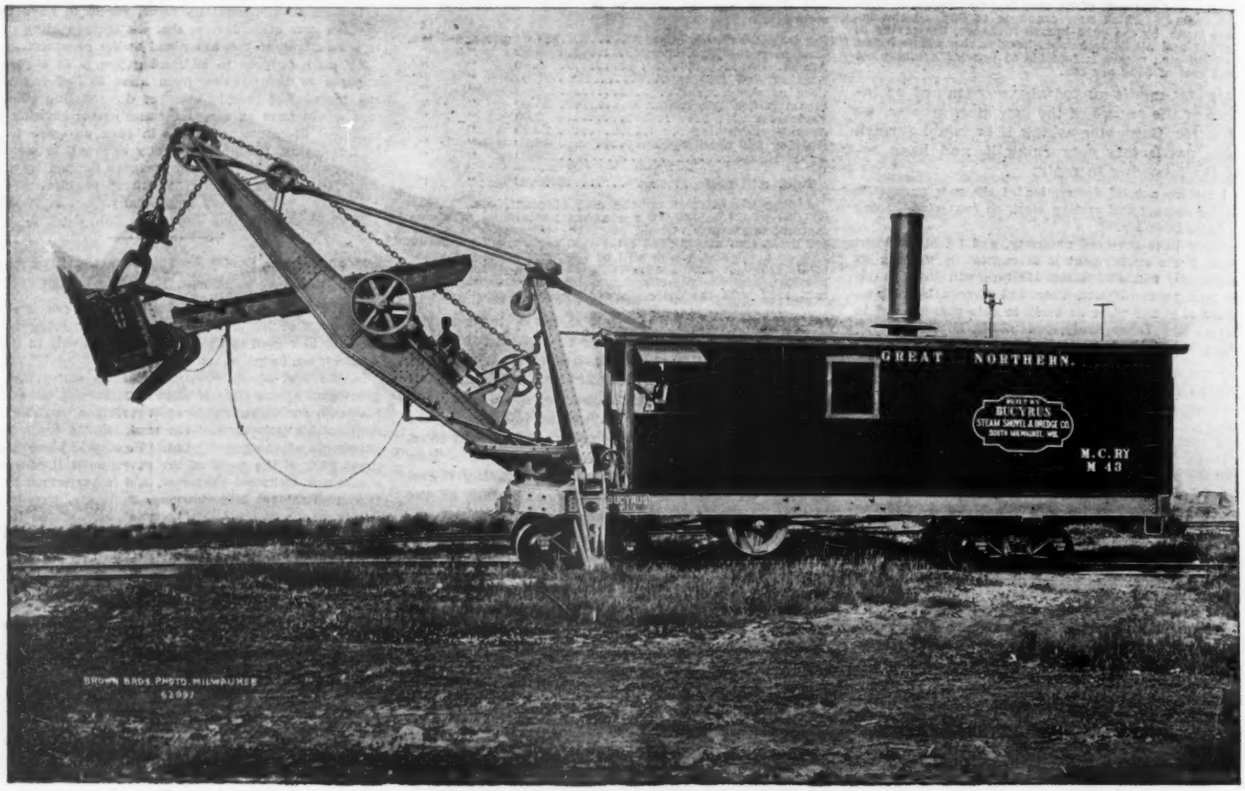


FIG. 1.—60-TON STEAM SHOVEL; GREAT NORTHERN RY.
The Bucyrus Co., South Milwaukee, Wis., Builders.

The records of the health department show that the factories of this company destroy in a completely sanitary manner over two hundred tons per day the year round of garbage—that is to say, refuse animal and vegetable matter. The compensation or bonus from the city for this work is about $60,000 a year. To work at a profit the company should receive twice this amount.

Whatever the factories of this company may have been in the past, before experience afforded sufficient wisdom to suppress all offensive odors arising from the treatment of garbage, the main factory is now in a perfect condition from a sanitary point of view, gives no offense whatever, and one similar to it might be run in the heart of any city without other offense than, possibly, smells in the streets from the carts conveying the garbage to the factory. This city does not pay for a daily removal of garbage. It contracts for the removal of garbage three times per week in the summer and twice a week in winter. The carts and wagons of the contractor, therefore almost invariably carry rotten garbage through the city, and until this oversight on the part of the city is amended, offense will continue to arise from the garbage carts, but so far as the factory of this company is concerned, there is no offense. A suit brought by complaining citizens, asking for an injunction against the working of the factory on account of odors therefrom, was summarily dismissed by the court last June with the emphatic statement, that, in the opinion of the

court it would be as physically impossible for odors to escape from windows and doors of this factory when in operation as it would be for a stream of water to pass through a pipe in opposite directions at the same time. The court also found that no odors came from the smokestack of the factory, and that if any odors were perceived by complaining witnesses, they must have been created by local causes, or by the slop carts of the contractor for the removal of garbage as they pass through the streets. The health commissioner and the board of health of the city confirm and indorse the verdict of the court, and, moreover, state in the last annual report of the health department that "Never within the history of the city, as far as remembered, has there been such a perfect condition of sanitary and healthful cleanliness as has existed for the past two years. The health department does not hesitate to attribute this desirable condition of affairs directly to the work of the St. Louis Sanitary Co."

We have gone thus into details in order to show you, for the benefit of your scientific readers, that there is one factory in the world, or in this country, which has solved the problem of garbage disposal without offense and is a success absolutely in every particular, except financially.

The factories of this and any other companies erected and operated for the destruction of garbage, that is to say refuse animal and vegetable matter, cannot be and will not be a financial success, unless a large bonus is paid by the city to help along the work. Revenue from the sale of products will never pay expenses.

Some parties may claim they are treating garbage at a profit. True, perhaps, in some instances, but only because their factories are situated where they can run "wide open" without any regard to sanitary conditions or where they are in a position to ignore the consequences. In these cases, immunity from trouble is only temporary. Sooner or later they will find that a great daily expenditure, to insure sanitary conditions, will be necessary and that their profits will be nil unless the city treasury steps in to their relief.

Respectfully, St. Louis Sanitary Co.,
Walter J. Blakely, Secretary.

St. Louis, Mo., Sept. 9, 1897.

(The St. Louis garbage disposal works were described and illustrated in our issue of Nov. 1, 1894. —Ed.)

A 60-TON STEAM SHOVEL FOR RAILWAY WORK.

The recognized economy of powerful machines of large capacity over smaller and lighter machines is leading railway companies to use larger and heavier steam shovels for gravel pit and general excavation, and the accompanying illustrations represent a 60-ton steam shovel designed specially for railway work, with a view to combining great capacity with rapidity of work, low cost of repairs, and a minimum of liability to breakdowns. The machine can make a cut 56 ft. wide and 4 ft. below the rail, and can raise the dipper so that its bottom door is 14 ft. clear above the rails.

The car floor is 37 ft. 6 ins. long and 10 ft. wide, the sills being heavy 15-in. I-beams, rigidly connected and braced, and the machinery is firmly secured to this heavy framing. The A frame is built up of plates and 8-in. channels, the base extending the entire width of the front of the car, and the top being fitted with a cast-steel head. This A frame and its single heavy back-guy form a rigid tripod, strains in which are provided for by pin connections of large size. The top of the frame is 17 ft. 6 ins. above the rail, the clearance limit on the Great Northern Ry. being 18 ft. From this frame is suspended the boom, which is composed of two steel plate-girders, the lower flanges of which are formed of steel I-beams with their webs horizontal, the object of this being to provide great lateral stiffness on the lower member against the strains due to rapid swinging of the boom. The dipper handle is of oak and steel, with very heavy fittings. The dipper has its shell made of one piece of ½-in. steel, and its capacity is 2½ cu. yds., while for soft material a dipper of 3 cu. yds. capacity can be used. It is attached to

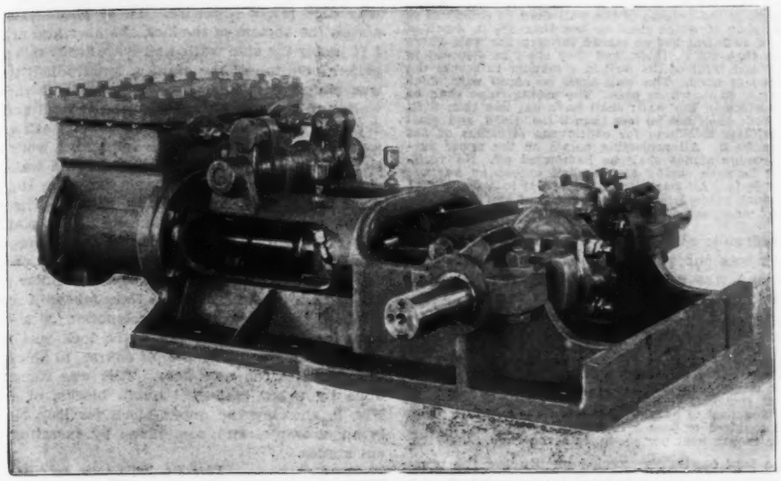


FIG. 2.—DIPPER ENGINES MOUNTED ON BOOM OF 60-TON STEAM SHOVEL.

the dipper handle by improved fastenings which do away with the ordinary forged side arms, and these fastenings take all the strains directly and have provision for the adjustment of the pitch of the dipper. Fig. 1 is a general view of the machine.

The main engines have the frames directly attached to the I-beams of the floor, and the guides are cast with the frame and then bored out. The two cylinders are 10 × 11 ins., and the cast-iron cross-heads are made in one piece, without any adjustments, the bearing surfaces of the cross-heads being as long as the stroke of the engine and of ample width, so as to reduce the wear. The hoisting friction gear is of the outside band type, lined with wooden blocks, and adjustable by a single nut. The thrusting movement of the dipper handle is performed by a pair of independent engines mounted on the boom and geared directly to the dipper shaft with double steel gears. These

Fig. 3.—Steel Truck for 60-ton Steam Shovel.

engines, which are shown in Fig. 2, are of strong and massive construction, the bed plate being cast in one piece and having heavy flanges on the inside to fit the boom, so as to form a rigid brace for the boom as well as a bed plate for the engines. The two cylinders are 7 × 7 ins., with flat slide valves, and the engines are reversed by means of a central valve. The crank shaft is of forged steel, and the eccentrics, which are between the cranks and in one piece, are forged solid with the shaft. Steam is supplied by pipes fitted with a bronze swivel joint, placed in the axis of revolution of the boom, as shown in Fig. 1. The engine can hold the dipper stationary against heavy strains, or can move it in or out independently of the main engines.

The hoisting chain is of 1¼-in. steel, and all the sheaves are 30 ins. diameter, as large sheaves run more easily and last longer, besides giving a longer life to the chain. All the sheaves are of cast-steel, with extra large bearing surfaces, and ample provision for lubrication. All the gears and pinions are also of cast-steel, and all parts that run loose on the shafts are fitted with bronze bushings. The swinging is done by a wire rope on a large sheave on the turntable of the boom, the swinging friction clutches being of a special type that give great power under easy control and do not heat in continuous work. As the machines work very rapidly, and can deliver four or five dipper loads per minute, a very high swinging power is needed, with great strength of parts to stand the strain of such rapid work. The method of swinging by the wire rope gives a smooth and easy motion which is specially advantageous for such work. Steam is supplied by a boiler of the locomotive type, with a barrel 54 ins. diameter, containing 2-in. tubes. It is designed for a working pressure of 125 lbs. per sq. in.

The machine is self-propelling and is mounted on two four-wheel trucks having diamond frames and steel box girder bolsters, formed of two I-beams with top and bottom cover plates, as shown in Fig. 3, the bolsters being carried by a nest of coiled springs at each end. The forward truck is directly under the heel of the boom, so that there is practically no overhang of the car frame. On each side of the front end of the car frame is a forged steel jack arm, with pin connections to the top and bottom members of a transverse truss over the forward truck center, the attachments being such that the jack arms form a continuation of the trusses. The side thrust on the A frames is thus carried directly to the bearings of the jack arms without straining the body of the car.

The machine was built by the Bucyrus Co., of South Milwaukee, Wis., and is one of the four built for the Great Northern Ry., while four more have been built for the Lehigh Construction Co.

THE NEW YORK STATE CANALS IMPROVEMENT.

II.

(With two-page plate.)

Deepening the Canal Prism.

The act authorizing the improvement work provided that the deepening of the canal prism might be accomplished either by excavation or by raising the side walls of the channel. As a matter of fact sometimes one method and sometimes the other was followed, but more often the walls were raised to provide for part of the increased depth and the remaining depth secured by excavation. On the profiles, Figs. 2, 3 and 4, published with the preceding article, each of these different methods is denoted by a separate symbol and the relative extent to which each method is to be used can be seen from the drawings. With this brief explanation the different classes of work required in deepening the canal prism, which will now be described, will be perfectly clear. The different methods of doing the work required will be described in a succeeding article.

Excavation.—Even with the accumulation of silt on the original canal bottom the depth of excavation was never very great. A number of typical cross sections chosen from the Frankfort Level of the Erie Canal, just west of Utica, N. Y., which are shown by Fig. 5, illustrate pretty clearly the forms the canal bottom had taken in different kinds of material. It may also be stated now that these same cross sections show the methods of improving the channel, the shaded area in each showing the new work. It will be noticed that generally the depth of excavation at the center is seldom over the required 2 ft., but at the sides the accumulation of silt makes several feet of digging necessary. It will be observed also that both earth and rock excavation had to be provided for.

The excavation proper was divided into wet excavation of earth and rock, and dry excavation of earth and rock. A peculiarly arbitrary definition of what constituted earth excavation was adopted

in the specifications. Briefly stated, both dry and wet excavation in earth included all material that in the opinion of the engineer could be plowed, and, besides this, all boulders of less than ½ cu. yd. contents, dry vertical wall, slope wall, paving, docking and cribs, and timber foundations of all descriptions. In regard to the classification of material as dry or wet excavation, the specifications had this to say:

It is distinctly understood that the words dry and wet are used only to distinguish excavation on sections of the canal that can be drained naturally or artificially from those sections where the canal cannot be drained or where its drainage is not contemplated, and where the materials must necessarily be removed by dredging. * * * * * Though the state reserves the right to permit the contractor to do any excavation that might be classed as dry, as above, by dredging if the contractor so prefers, at the prices named for dry excavation.

The same interpretation of the words dry and wet also applied to rock excavation, which included boulders measuring ½ cu. yd. or more, and all material that in the opinion of the engineer could not be plowed.

Except when used in grading and filling embankments, bridge approaches, roads, etc., the spoil from the channel was dumped on regularly defined spoil areas, or, in the case of dredged material, in places chosen by the contractor and satisfactory to the engineer. When used in grading and filling, the spoil was paid for as embankment if, in the case of dry excavation, it must necessarily be hauled more than 1,000 ft., or, in case of wet excavation, it must necessarily be unloaded from scows, or, in the case of excavation and filling around masonry structures, the material must necessarily be handled twice.

Lining and Puddling.—To fill around foundations and behind walls and to provide against leaks, gravel and broken stone lining and loose filling and clay and gravel puddling were used quite extensively. The extent and character of these constructions were naturally quite variable. Some of the most common uses of gravel lining were on the tops of embankments and behind slope walls, as shown by Fig. 6. Beyond the fact that this work was done carefully with selected materials, it needs no particular mention. Asphaltic concrete was also used to some extent in lining the sides and bottom of the channel. This material was simply a mixture of broken stone and asphalt, properly heated and mixed and laid on a good foundation bed to such a thickness as might be desired.

Vertical and Slope Walls.—In many places the nature of the material or other reasons made it necessary to define the limits of the channel by vertical or slope walls. Wherever old walls of these kinds existed, of course, they were simply extended to suit the increased depth, unless their deterioration or destruction during the excavation required partial or entire reconstruction. Sometimes, also, it was deemed desirable by the engineers to build such walls where none had existed before. A pretty clear idea of the nature of this wall-work is given by Fig. 5, and particularly by Fig. 6, in which the unshaded area always indicates the original work, and the shaded area the repairs and extensions.

Where stone masonry was used for vertical walls, undressed quarry stone were employed and were laid dry or with Portland or natural cement mortar, as the nature of the foundation and the impermeability and strength of the wall needed seemed to demand. The quality of the vertical wall masonry in cement mortar is thus stated by the specifications:

The wall to be built of sound, durable and well shaped quarry stone acceptable to the Resident Engineer. Stone shall not be less than 3 sq. ft. area of bed nor less than 6 ins. in thickness, nor have depth of bed less than 12 ins., and all stone more than 12 ins. thick shall have a depth of bed equal to thickness, but such limited use of stone smaller than these dimensions as in the opinion of the engineer is necessary for levelling up face stone, or spalling backing, will be allowed. The stone to be laid on their natural beds, properly bonded, and projecting points on face and top to be hammered off as may be directed by the engineer. From the face extending at least 6 ins. into the wall, vertical joints shall not exceed ¾-in. in width. One-fourth of the volume of the wall shall be composed of headers, none of which shall be less than 2½ ft. depth of bed, or of sufficient bed to extend through the wall where it is less than 2½ ft. thick, and they shall be disposed in the back and front of the wall in a manner to secure the most efficient bond. The wall shall be coped with stone or concrete, as shown on plan. The coping stone shall be the full width of the wall; shall have not less than 6 ft. area of bed; shall not be less than 8 ins. thick, and shall be of uniform thickness for continuous stretches of not less than 30 ft. All projecting points on the upper surface of coping stones shall be hammered off. No vertical joint between coping stones shall exceed an average width of ¾-in. All joints to be raked out to a depth of 1 in. and flush pointed, with mortar made of one part of cement and one part of clean, dry sand.

All hydraulic cement used for mortar or concrete in work was subjected to tests by the State Engineer and was required to exhibit the following qualities:

Portland cement:	
Amount required to pass a 2,500 mesh sieve.....	95%
Amount required to pass a 10,000 mesh sieve.....	90%
Tensile strength neat per sq. in, in seven days....400 lbs.	
Tensile strength 1 cement, 3 sand mortar per sq. in. in seven days..... .....125 lbs.	
Natural cement:	
Amount required to pass a 2,500 mesh sieve.....	90%
Amount required to pass a 10,000 mesh sieve.....	80%
Tensile strength neat per sq. in. in seven days.... 65 lbs.	

In the first contracts carried out during the winter of 1896-7, all concrete used in the vertical and slope walls, as shown by Fig. 6, and also that used in other parts of the work, was of the following compositions: Portland cement concrete, one part cement, three parts sand and six parts broken stone; natural cement concrete, one part cement, two parts sand, and five parts broken stone. For succeeding work the specifications for concrete were altered, making the composition of Portland cement concrete, one part cement, two parts sand and five parts broken stone, and of natural cement concrete, one part cement, two parts sand and four parts broken stone. This alteration was deemed advisable on account of the fact that all of the work is done in freezing weather, and it is important that the mixture should be rich enough to set quickly and be capable of carrying the load placed on it in a short time.

Deepening Locks.

The deepening of the locks to correspond to the increased depth of the channel was accomplished by lowering the floor or by raising the side walls, or by a combination of the two methods. The raising of the walls was very simple work, as it consisted merely in placing an additional course of coping laid in Portland cement mortar and clamped and doweled to the old masonry. To lower the lock floor, however, was a somewhat more difficult task, as the old side walls had to be shored up and underpinned with new material. Fig. 7 shows the plan adopted by the State Engineer for doing this work. The lock chamber was first braced across from wall to wall to prevent the walls from yielding sideways. The faces of the side walls were then dressed back to receive the iron side plates. This preparatory work being finished, the old foundation timbers were cut off even with the side walls two or three at a time and the earth underneath excavated to the required depth. On the bottom of the excavation a foundation bed of concrete was then laid, and on top of it was placed 3×10-in. Norway pine plank edgewise. These plank extended across the bottom of the lock chamber, and at least 1 ft. under the side walls, and were firmly spiked together. On top of the plank a longitudinal timber was placed with its outer edge even with the side wall, and then on top of this longitudinal and under each old foundation timber a white oak wedge was driven to refusal. The remaining work consisted in filling all interstices under the wall with Portland cement concrete, and fastening the iron plate and angle, as shown by Fig. 7. The floor of the lock chamber was laid with 2½-in. plank.

The deepening of the locks, of course, required new gates. "Tumble" gates have been used in some cases at the heads of locks, but miter gates are generally used, and all thus far built are of wood. Fig. 8 shows the construction of a miter gate for lock No. 46. When the lock was deepened the hollow quoin had, of course, to be continued down to the new floor. This was sometimes done by using cast-steel quoin blocks, of which Fig. 9, showing the quoin block for lock No. 46, is an example, and sometimes by inserting new cut stones.

Lift Locks.

In 1885 work was begun lengthening the old 110 × 18-ft. locks to 220 ft. (about 210 ft. in the clear), and up to the present time 42 of the 72 locks have been lengthened. Of the 30 locks yet to be dealt with, many are bunched in groups or flights, as, for instance, at Cohoes, N. Y., where 16 locks effect a change of level of 140 ft., and at Lockport, N. Y., where five locks effect a change of 57 ft. It is practically impossible to lengthen these locks in the same way that the others have been, and for some time the substitution for them of vertical lift locks has been contemplated. Plans have been completed for the lift lock at Lockport, and submitted to the Superintendent of Public Works for approval, but owing to the condition of the finances he does not deem it expedient to advertise for the construction of the lock at present, preferring to use the money now available for deepening the prism, and leaving the work of lengthening the locks to be provided for by future appropriations, which it is now considered will be absolutely necessary to finish the canal improvements. The plans for the lift lock at Cohoes have been carried far enough to afford a basis for reliable estimates of cost.

For the benefit of those who may wish to review what has been done heretofore in the construction

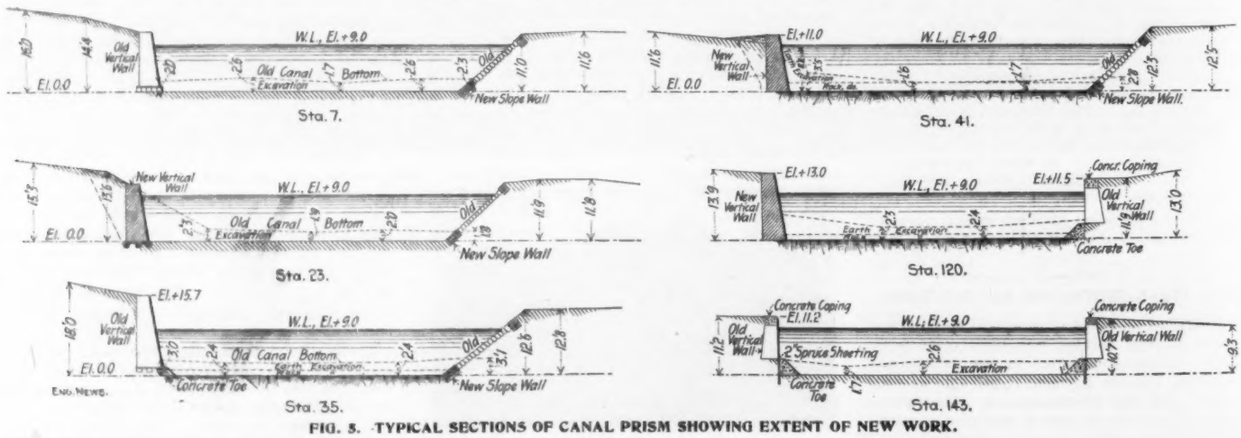


FIG. 5. TYPICAL SECTIONS OF CANAL PRISM SHOWING EXTENT OF NEW WORK.

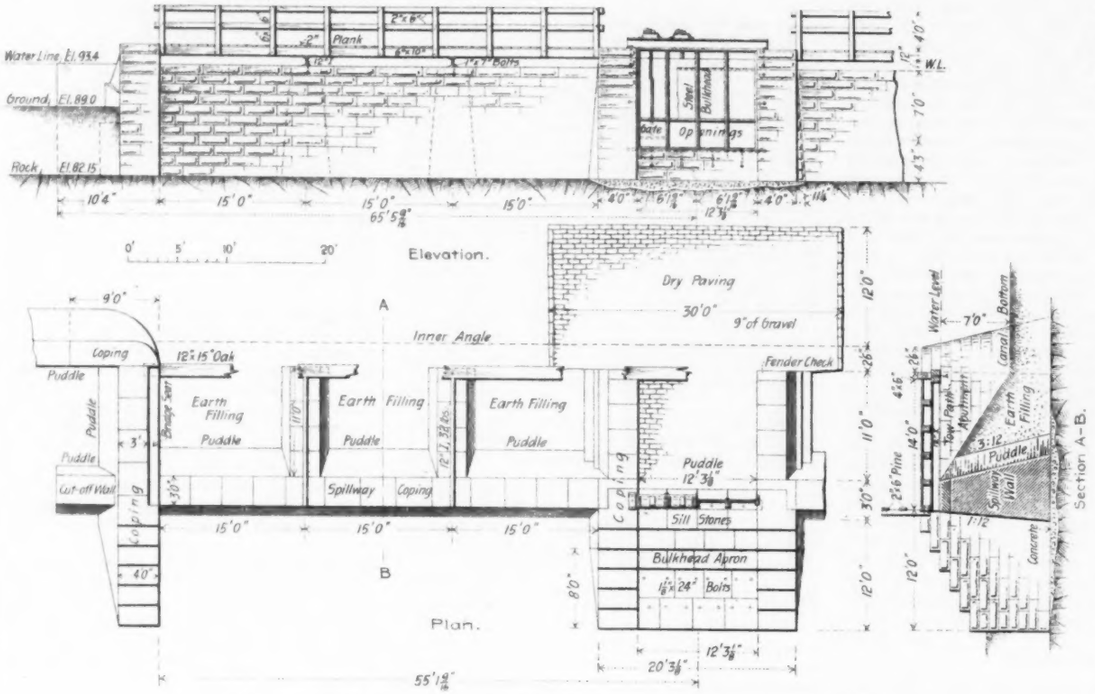
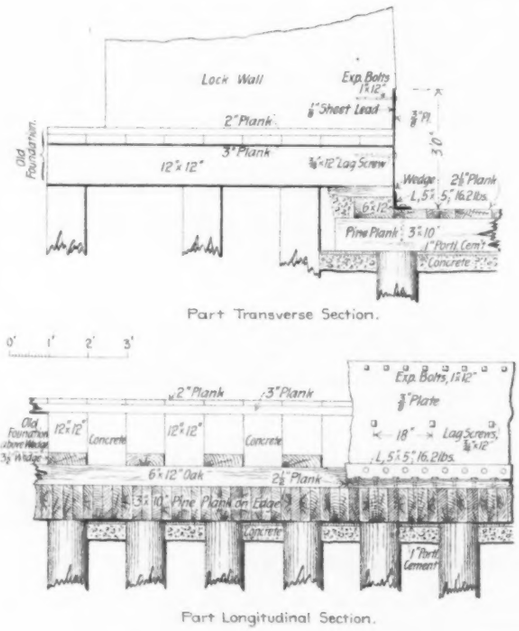


FIG. 11. NEW WASTE WEIR AT MECHANICSVILLE, N. Y., CHAMPLAIN CANAL.



FIGS, 7. METHOD OF UNDERPINNING LOCK WALLS.

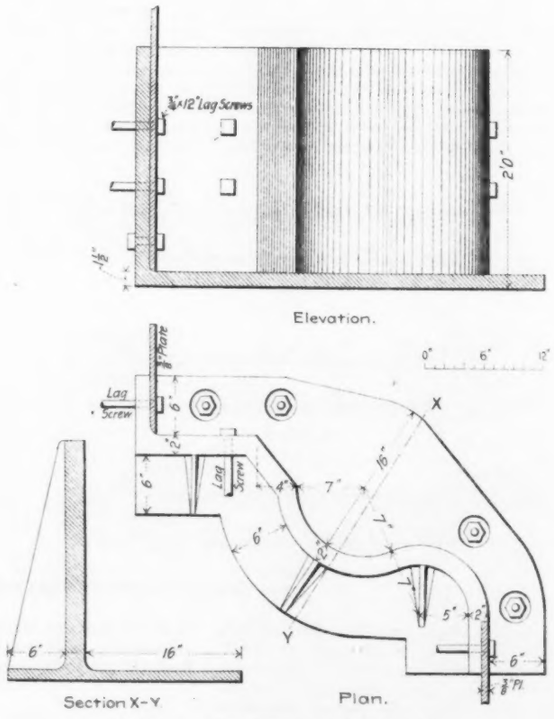


FIG. 9, CAST STEEL QUOIN BLOCK USED IN DEEPENED CANAL.

NEW YORK STATE CANALS IMPROVE

Campbell W. Adams, State Engineer and Surveyor.

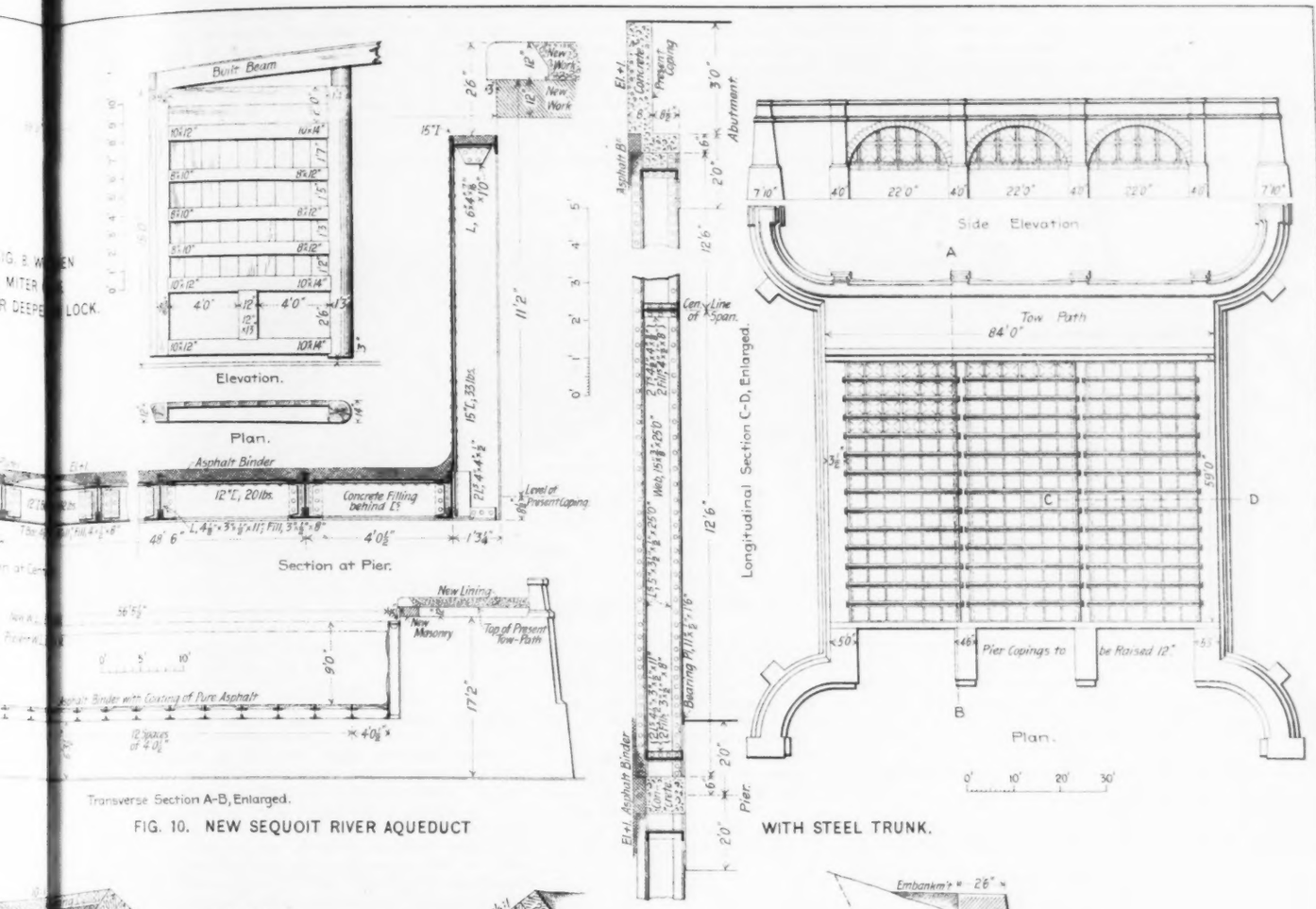


FIG. 10. NEW SEQUOIT RIVER AQUEDUCT WITH STEEL TRUNK.

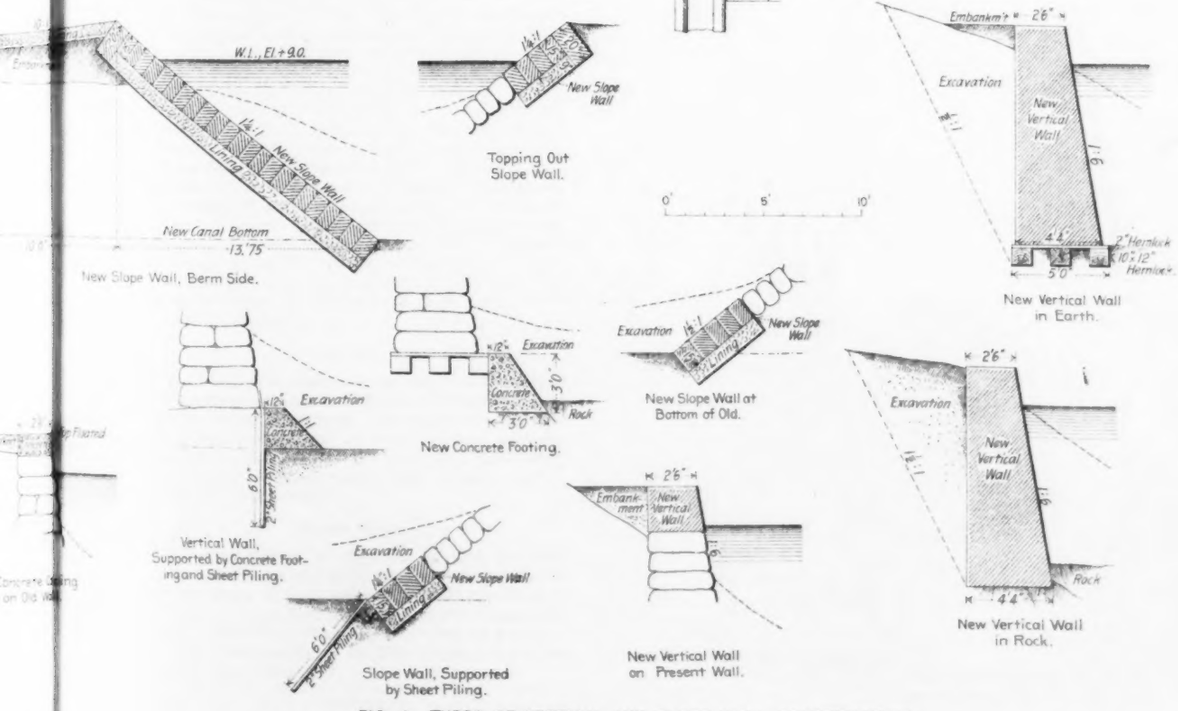


FIG. 6. TYPES OF VERTICAL AND SLOPE WALL CONSTRUCTION.

MPROVEMENT. STRUCTURAL DETAILS.

Herschel Roberts, Deputy State Engineer and Surveyor.

CHAS. HART & SONS, LITH., 35 VESEY ST., N. Y.

of lift locks, and also to study the investigations made by the State Engineer of New York, Mr. Campbell W. Adams, regarding their application to the Erie Canal, we refer to the very complete articles in Engineering News of April 18, 1895. It may be said in conclusion that if the work at Lockport proves satisfactory, one or more lift locks

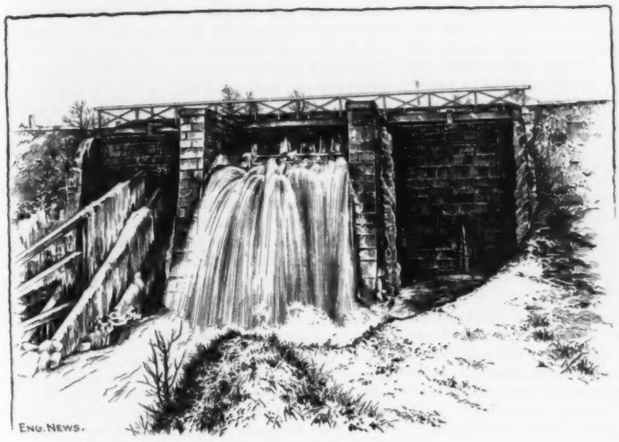


FIG. 12.—OLD WASTE WEIR.

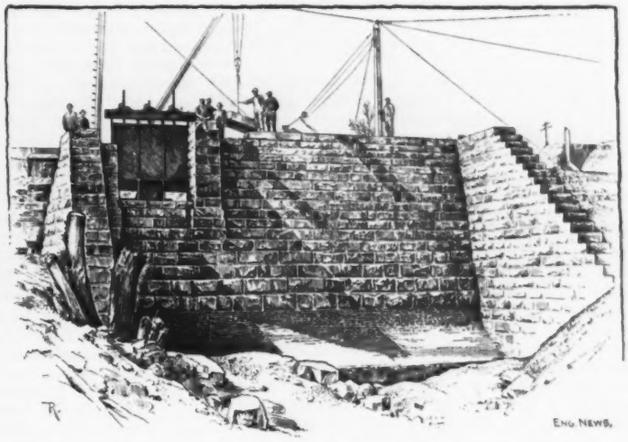


FIG. 13.—NEW WASTE WEIR.

FIGS. 12 AND 13. OLD AND NEW WASTE WEIRS AT CARTERSVILLE, N. Y., ERIE CANAL.

will be substituted for similar flights of old locks at other points on the canal.

Aqueducts.

Contrary to what might be expected, the deepening of the water over aqueducts will not be very expensive or difficult. Most of these structures consist of a timber trunk or trough carried by masonry piers connected by arches to carry the tow path. One of these aqueducts is shown by Fig. 10, except that the drawings are for the new steel buckle plate trunk. Some of the other structures will be handled in the same way, but in other cases the placing of a 12 × 12-in. timber on the top of the present timber construction will accomplish the desired result, while in still other instances the present timber construction will be dropped 1 ft. on the piers and abutments and 2 ft. of timber added to the top. The stone arch aqueduct at Rochester, N. Y., is probably the most difficult one to handle, but the required depth in this structure can be secured by reducing the thickness of the arches at their crowns and changing their forms somewhat. It will, of course, be necessary to cut out and relay the major portion of the arches. The difficulty in nearly all cases is the lack of efficient waterway under the aqueducts, and in some cases this difficulty is so marked that it has been the deciding factor in determining how the level should be deepened.

Culverts.

In a number of instances the culverts for carrying crossing streams underneath the canal had to be lowered and enlarged. Generally the old culverts consisted of one or more wooden conduits laid side by side, and in the new work these were replaced by cast-iron pipes, with masonry abutments and wing walls.

Waste Weirs.

The illustrations in Figs. 12, 13 and 14 show quite clearly the character of the new structures of this class. Fig. 12 gives the detail drawings of the new weir at Mechanicsville, on the Champlain Canal, while Figs. 13 and 14 show the old and new weirs at Cartersville, on the Erie Canal, a few miles east of Rochester, N. Y.

Bridges.

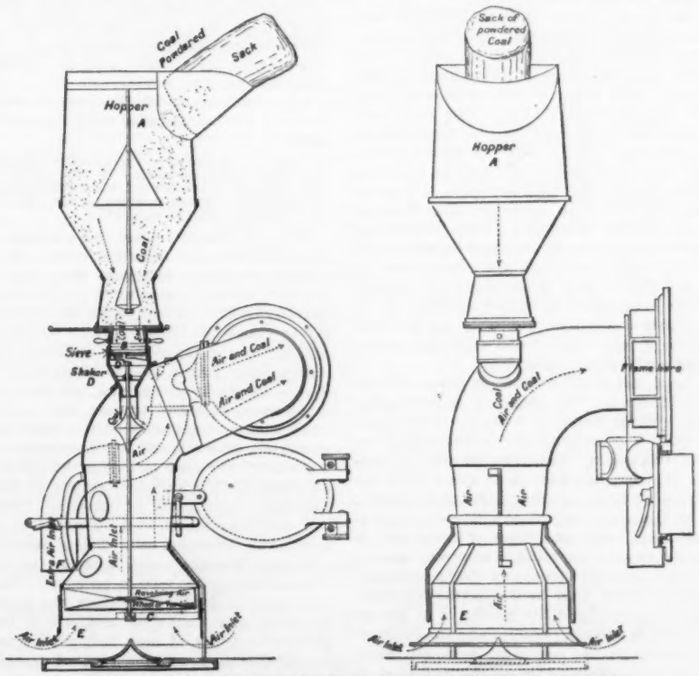
The bridge-work necessitated directly by the present improvement consisted only in raising the abutments or of underpinning the masonry, where the deeper channel required such changes, and the modification of the approaches to suit the new conditions.

BURNING POWDERED COAL UNDER STEAM BOILERS.

A series of experiments has recently been conducted in New York city on a new method of burning finely-powdered coal, invented by Mr. Carl Wegener, a German engineer. The tests were made under a horizontal return tubular boiler in a steam laundry at the foot of East 116th St., and were in charge of Prof. Jas. E. Denton, M. Am. Soc. M. E., of the Stevens Institute of Technology. Mr. Bryan Donkin, M. Inst. C. E., of London, who has been traveling in this country for six weeks, and Mr. F. W. des Tombe, agent of the Wegener system for the United States, were also present. By their courtesy a member of the staff of this journal had an opportunity of witnessing one of the tests and to obtain a complete description of the apparatus used.

The first trials of the Wegener system were made by Mr. C. Schneider, in Berlin, in 1892. In 1895 various trials were made by him with English coal, Bohemian lignite and Upper Silesian hard coal. The results showed a boiler efficiency of 79% with the English coal, and 78% with each of the other coals. The chimney gases contained from 11 to 14% of carbon dioxide. The quantity of smoke was practically nil. Since 1895 the Wegener system has been adopted for 15 or more boilers in Berlin, for a Belleville boiler in Paris, and the first apparatus in England has been started at the factory of Messrs. Bryan, Donkin & Co., at Bermondsey. We glean these facts from a paper by Mr. Donkin, in a pamphlet advertising the system, published in London, and from it also we take the following description and the accompanying illustration of the apparatus:

Small sacks of powdered coal, weighing about ½ cwt., are either put into a conical hopper, A, or the coal is automatically fed into the hopper by screws or worm. The powdered coal gradually falls out of the sacks, as required, into the hopper, and then on to a sieve, B, about 5½ ins. in diameter, with small openings in it. The powdered coal would not go through this sieve with certainty without continually tapping, and this is done in the following way: Immediately beneath the hopper, and level with the boiler-house floor, is an air pipe about 20 ins. in diameter, through which nearly all the air for combustion is admitted. As it enters it is made to pass through the blades of an air wheel or turbine, C, and this passage of the air causes the latter to revolve. On the axis of this air wheel is a little knocker, which taps the sieve from 150 to 250 times per minute, causing the powdered coal to descend vertically through the sieve, meeting the air for combustion as it descends vertically. In this way the coal and air get thoroughly mixed, and pass on into the boiler-flue, each particle of coal being surrounded by air. The stoking simply consists in putting the sacks of powdered coal, from time to time, into the top of the hop-



MACHINE FOR BURNING POWDERED COAL UNDER STEAM BOILERS.
Carl Wegener, Germany, Inventor.

per, and seeing that the right amount of air is entering for combustion. If there is not sufficient air for proper combustion entering through the main opening, as seen by a little smoke, there are two other smaller pipes where additional air can be admitted, each kind of coal requiring a somewhat different amount. The only object of the air-wheel revolving from 50 to 80 revolutions per minute is to shake the sieve and cause the powdered fuel to enter the furnace in the quantity desired. When more steam is required a greater knock is given to the sieve, and more powdered coal is burnt; when less is needed, a less shake is necessary. An adjustment is provided to regulate the amount of coal entering, which is done by turning with two fingers a ½-in. screw. One man can attend to several boilers. The ignition of the powdered coal takes place immediately on its arrival in the hot firebrick chamber, and about 1 foot from the boiler front.

The pamphlet from which this description is taken also contains the reports of several tests of boilers fired with the Wegener apparatus, at Berlin, Berne, Paris and Brussels. The results may be briefly summarized as below:

A Cornish boiler at Berlin, tested by Mr. Donkin, gave with hand firing a thermal efficiency of 54%, with the Wegener system 77%. The rate of evaporation per sq. ft. of heating surface in the first test was 2.23 lbs.; in the second, 3.15 lbs. The mean analysis of the gases in the first test was CO_2, 8.73; O, 8.13; CO, 0.88; in the second test CO_2, 15.35; O, 3.14; CO, 0.0. The temperature of the chimney gases in the first test was 438°; in the second, 413°. In the first test, lasting 7.1 hours, smoke was observed 70 times, lasting in all 105 minutes, and in the second test, of 6.66 hours, smoke was observed only 7 times, lasting in all 6 minutes. In the report of these tests it is stated that "grinding of coal into fine powder increases first cost of coal about 10%."

A Cornish boiler tested at Berne, Dec., 1896, by Mr. J. A. Strupler, for the Swiss Association of Steam Boiler Owners, gave a boiler efficiency in four tests with ordinary grate and hand firing ranging from 57.7 to 62.2%, averaging 59.7%; and in four tests with the Wegener apparatus, from 70.2 to 74.2%, averaging 72.2%. A diagram giving the "smoke record" shows a frequent emission of intense black clouds with hand firing, and scarcely any smoke when the powdered fuel apparatus was used. A diagram giving the percentage of carbon dioxide in the gases shows that it was very irregular with hand firing, ranging from below 5 to above 9%, while with powdered fuel firing it was quite regular, ranging from 9 to 11%.

Eight experiments made at Paris, with an "elephant" boiler, using the Wegener system only, gave an evaporation from and at 212° per lb. of dry coal, in four tests with marine briquettes, ranging from 9.74 to 10.73 lbs.; in two tests with Mons coal, 10.83 and 11.43 lbs.; and in two tests with French coal, 10.34 and 11.36 lbs., but as comparative tests with hand firing were not made, and as neither the heating value of the several coals nor their percentages of ash and moisture are given, the figures tell us nothing of the relative merits of the Wegener system as compared with hand firing.

Two experiments made at Brussels on a De Naeyer water-tube boiler, one with hand firing and one with powdered coal, gave respectively 7.1 and 9.5 lbs. of water evaporated from and at 212° per lb. of coal, but it is stated that "probably the coal was not the same in both trials," and that the heating value of the coal was not taken.

A statement dated July, 1897, is given in the pamphlet concerning the progress the Wegener system has already made in Europe, from which we learn that a company, the "Gesellschaft fur Kohlenstaubfeurungen," has been formed to supply Berlin, that licenses have been granted to various engineering firms in other parts of Germany, and that in Germany 100 of the Wegener appliances have been made and most of them are at work; that in Austria a syndicate has been formed by three manufacturing firms, and that a company will be formed later; that in Switzerland a company has been started and the system is in use by two firms; that in France, Belgium and the Netherlands the shares of the company were all taken up before the completion of the trials; and that in Russia, Sweden, Denmark and Chili, the system is in use in several places.

After our observation of the Wegener apparatus in New York city, and a study of the results shown in the pamphlet, we feel bound to say that, notwithstanding the apparent success of the system in Europe, its extensive introduction in the United States is very improbable. It is handicapped in the first place by the expense of grinding the coal to such a fineness that it will all pass through a sieve of 125 meshes to the linear inch, which expense the pamphlet admits will be 10% of the cost of the coal. In the experiment in New York the coal is ground in a buhr stone mill which discharges it into a box from which it is shoveled into sacks which are carried to and emptied into the hopper. The space occupied by this grinding apparatus in a large boiler plant, the uncleanliness of the operation, and the double handling of the coal will all be serious objections to the use of the system. The tests made in Europe show that the economy is greatly superior to hand firing in these particular tests with Cornish boilers, but these hand firing tests showing 54 to 59% boiler efficiency cannot be considered as equal to even average results with hand firing in this country, and are far inferior to our ordinary practice with hand firing and properly proportioned boilers with all coals mined east of the Allegheny mountains, which in expert tests frequently shows an efficiency of 75% or more. For our Western coals, in which efficiencies as low as 50% are not uncommon with hand firing and ordinary furnaces, the Wegener system should not be compared only with hand firing, but also with other improved methods of burning bituminous coals, such as the Hawley down-draft system, the under-feed screw and other forms of mechanical stokers, and with fire brick furnaces, by which means the results obtained by the Wegener system, both in economy and in smokeless combustion, may be fully equalled without the expense of 10% of the cost of the coal for grinding, and the cost of installation, royalty, etc., of the powdered fuel system.

The particular means used by Mr. Wegener for burning powdered fuel, by which he dispenses with the use of forced draft, appears to be new, and it is highly ingenious and efficient; but in not using forced draft he limits the capacity of the apparatus. There is no reason, however, why forced draft cannot be used with it, if found advisable. Forced draft systems of burning powdered fuel have been experimented with repeatedly since the extensive experiments of Mr. Crampton, in England, from 1868 to 1873, which were abandoned after the expenditure of a large sum of money and the grinding of some 2,000 tons of coal. It is not easy to see how the Wegener system can be superior to the Crampton, except in the saving of the expense of installation and of operation of the fan blast used by the latter.

In the article by Mr. Donkin, to which we have referred above, he states that the use of powdered fuel

is based on the principle universally admitted by scientific men, that coal cannot be thoroughly burnt unless each particle is surrounded with sufficient oxygen to insure perfect combustion, and this can only be effected by first reducing the coal to powder.

We cannot believe that this principle is "universally admitted by scientific men." It is purely a fallacy, for anthracite coal may be thoroughly burned, without reducing it to powder, by simply surrounding the lumps by a sufficient supply of hot air to cause the carbon, which burns only on the surface of the lump, to be oxidized to carbon dioxide; while in the case of bituminous coal, which distils off hydrocarbon gas, all that is necessary is to cause this gas to pass into a very hot fire brick chamber supplied with a sufficient quantity of hot air, where it will be burned thoroughly without smoke, the coke left after the distillation being also burned by a sufficient supply of hot air. This thorough combustion of lump or "run of mine" soft coal may be effected by means of well-known apparatus which is now being extensively used with our Western coals, without the necessity of "first reducing the coal to powder." The Wegener apparatus undoubtedly effects the same result of thorough and smokeless combustion but with no greater economy of coal, and with what seems to us considerably greater cost of installation and operation.

AMERICAN RAILS FOR INDIA.

Some excitement has been raised in England by the announcement that contracts for rails for India have been awarded to American rolling mills, but the government officials who authorized the contracts stated that the rails complied with all the requirements as to quality and would cost only about $23.50 per ton, as against about $27.50 per ton bid by the English rail mills. The Maryland Steel Co., of Sparrows Point, Md., has a contract for T-rails for the Bengal & Nagpur Ry., and double-head rails for the East Indian Ry., both of which railways are government lines operated by companies.

The double-head rail is 5 3-16 ins. high, and the heads are 2 5-16 ins. broad. The web is ⅞ in. thick, and the weight is 85 lbs. per yd. It has the old-fashioned rounded head, and in fact is an old-fashioned section, which has been largely abolished for the bull-head rail, in which the two heads are, as a rule, not symmetrical, but the lower head is only large enough to give a seat in the cast-iron chair, and a hold for the wooden block which secures the rail in the chair. The original idea of the double-head section was that when one head was worn the rail could be turned upside down and used as a new rail. As a matter of fact, however, the lower head is so indented at the points where it rests in the chairs, that this head makes a very hard riding track if the rail is turned. It is also said that such inverted rails are quite likely to break.

THE SUMATRA RACK RAILWAY, lately constructed, is said to be the first of its kind built purely for industrial purposes over any considerable length of line. It forms a part of the Sumatra State railways and crosses the Barisan Mountain range; commencing at Kajoe Tanam, on the west slope, it reaches Padang-Pandjang, on the summit, and Batoe Tabal, on the eastern slope. A branch line is being constructed from Padang-Pandjang to Kota Baroe. This line is built for conveying coal from rich mines on the River Ombilien to the new port of Padang, opened in 1891. As described more fully in "Engineering," the total length of the rack railway is 19 miles; the greatest elevation overcome is 3,875 ft.; the maximum incline is 8%, and the maximum radius of curve is 492 ft. The rack is of the Riggenbach type, or is made of two soft steel channels joined by riveted pins; this rack is bolted to cast-iron chairs fastened to steel sleepers, which latter also carry the ordinary rails. The gage is 3 ft. 6 ins. The rack locomotives are also of the Riggenbach type and were built by the Esslingen Engine Works, near Stuttgart. Each car on the train, passenger and freight, is provided with an effective hand-brake, to be used in helping the locomotive in an emergency. The maximum train loads are 65 tons up and 70 tons down for the steep western slope, and on the east side, 90 tons for up trains and 110 tons down. The mean speed is 8 miles per hour.

A LIGHTSHIP IS TO BE PLACED ON DIAMOND Shoal, off Cape Hatteras, by order of the Lighthouse Board. This vessel would be the strongest ever built for such service, as she would be anchored in 30 fathoms of water, about 15 miles from the present Hatteras lighthouse, and inside the ledge beyond which the water deepens to 100 fathoms. She will display a fixed white light for 12 seconds, followed by an eclipse of 12 seconds. The six lens lanterns will be electric and be placed 57 ft. above the water and thus visible, on a clear night, for 15 miles. A 12-in. steam chime-whistle will, in foggy weather, blow blasts of 5 seconds duration separated by silent intervals of 45 seconds. Captain Robley D. Evans, U. S. N., and for some years naval secretary of the Lighthouse Board, is opposed to the project and declares that no chain can be forged that will hold a vessel on this shoal for any length of time. He says that the current drives the sand around at such a rate that the links will be cut, or so weakened as to fail under the first heavy gale. But Captain F. Wildes, the present Naval Secretary, believes that a lightship can ride out a gale off Hatteras as well as a similar vessel stands the gales on South Shoal.

THE RATE OF PIG IRON PRODUCTION increased rapidly during August, the weekly capacity of furnaces in blast on Sept. 1, according to the "Iron Age," being 185,506 gross tons, as compared with 165,378 gross tons on Aug. 1. The stocks of pig iron were reduced during the month from 933,958 to 869,110 tons. The long expected revival in the iron trade is now fairly under way. Prices have advanced moderately, and many furnaces which have been idle for a long time are preparing to go in blast.

THE TRANS-MISSISSIPPI AND INTERNATIONAL Exposition is to be held at Omaha in June—November, 1898. The Manufactures Building has already been designed by S. S. Beman, of Chicago, and may be described as follows: In architecture it is Greek Ionic, with a stepped circular dome, 150 ft. diameter and rising to a height of 75 ft., as the principal feature of the lagoon facade. This circular dome rests upon fluted Ionic columns, which form an open domed approach vestibule. Flanking this central dome are Ionic colonnades forming covered ways along the whole front of the building. The four corners of the building are marked by square, plain towers

surmounted by ornate, open columned, circular pavilions, which will be used for electric lighting. This whole building will be 300 ft. long by 140 ft. wide.

ADVISORY COMMITTEES OF THE INSTITUTION OF Civil Engineers, of London, have been established in all the colonies of Great Britain and in South Africa. The purpose of these committees is to advise the council of the Institution upon application for membership and in other matters of a local nature. The plan has worked very satisfactorily, and an effort is now being made to establish a similar committee in the United States. Mr. E. L. Corthell, M. Am. Soc. C. E. and M. Inst. C. E., has been requested to take the preliminary steps in organizing the committee, and the Corporate Members of the Institution in the United States, approving the propositions, are asked to select seven or eight Members for this duty.

EXPERIMENTS IN HIGH-ANGLE FIRING have been recently conducted at Woolwich, England. The gun used was a 9.2-in. wire-wound Service gun, weighing 19 tons, and discharging a 38,216 Palliser projectile with 270 lbs. of powder. This gun was mounted on a special high angle carriage, and for the maximum range attained of 12 miles the angle of elevation was 40°. It was calculated that at this range the shot reached a height of 16,000 ft., or about three miles, and the time of flight was exactly one minute. The English ordnance authorities regard the experiment as of great importance in the defense of ports against sea attack, and claim that great accuracy of fire is possible. But, as a matter of fact, the United States government has already in position at several of its ports batteries of 12-in. steel breech-loading rifled mortars which were designed to do exactly the same thing, and with which some wonderfully accurate shots have been made at 9 miles range, with 830-lb. steel shells. The American gun is larger, cheaper, simpler in construction and manipulation, and has proven that it is quite as efficient as this "advance" in British ordnance.

ANNUAL MEETING OF THE MASTER CAR AND LOCOMOTIVE PAINTERS' ASSOCIATION.

The 28th annual meeting of the Master Car and Locomotive Painters' Association was held at the Hygiea Hotel, Old Point Comfort, Va., Sept. 8, 9 and 10, 1897.

There was a large attendance of delegates, and all the sessions of the meeting were well attended. Forty new members were received.

After the address of the President, Mr. C. E. Copp (B. & M. R. R.), and the report of the Secretary and Treasurer, Mr. Robert McKeon (Erie R. R.), the reading and discussion of papers was taken up.

The first report was on "Protective Paint for Metal Parts of Cars and Trucks," a subject which had been referred to this Association by the Master Car Builders' Association. Mr. J. H. Pitard (M. & O. R. R.), a member of the committee, said: "There are no anti-rust paints; the virtue of the protective coverings rests entirely with the binding material, and thus the oil or varnish that is nonporous, and forms the most impervious coating, to thoroughly exclude the moisture and atmosphere will prove the most effective covering for metal. The nature of the pigment is a secondary consideration. The preference is accorded, however, to pigments that are of a low specific gravity and are not themselves susceptible to atmospheric influences. Graphite does not absorb the oil or binding material and is doubtless better for the finishing coat, but some pigment, such as a mineral paint, which does absorb oil, would be preferable as a primer, as in that case the drying is greatly facilitated. Rust and mill scale must first be removed before painting, otherwise the result will be unsatisfactory. A mere brushing of the surface with wire brushes will not suffice; but every particle of rust must first be extracted from the pores of the metal before painting, or bad results are sure to follow.

Mr. Ball (P. R. R.) described a test of several samples of pigments which were exposed over 15 months. The samples were: (1.) Red lead, with a small amount of litharge, sufficient to dry fast, and raw linseed oil. (2.) Red lead and linseed oil, without drier. (3.) Half red lead and half lamp black. (4.) ¼ red lead and ¾ lamp black. (5.) Mineral metallic paint, red oxide of iron. (6.) Mexican graphite. All the samples, except the first, were mixed simply with raw linseed oil, without any drier. After the exposure the red lead and litharge coating had given way in two or three spots; the straight red lead was intact and appeared to be good for several years to come. The mixture of half red lead and half lamp black had scaled off in several places, showing rust. The red lead and three parts lamp black was in still worse condition. The oxide of iron was completely gone. The graphite was in perfect condition, the same as the straight red lead. All samples were painted at the same time, with the same quantities of oil and had the same exposure."

In concluding the discussion the following was adopted:

Resolved, That it is the sense of this Association that any first-class pigment, mixed with a first-class quality of linseed oil, properly applied and cared for, will answer all purposes for all metallic parts of cars or locomotives or structural iron, which it is proper to paint with an oil paint.

In the paper by J. H. Kahler (Erie R. R.), on "Painting Railway Equipment With Compressed Air," the writer said: "A great deal of fault is found in the working of different machines, owing to the spray produced filling the atmosphere with a light floating mist through the shop when working indoors; but with a properly constructed device, the paint formulated right, and sprayed with the proper pressure of air, this trouble is reduced to a minimum. For rough repaired freight cars the spray painting surpasses the brush, as the paint is blown into all bruises and roughness of surface without the usual amount of brushing by the old way. Far better work, with less material, is the result. Paint spraying has proved a success in doing freight cars, by reducing time in shop and cost of brushes. Cars can be got into service more quickly than by the old way with the brush, which is a gain to the railroad companies when the cars are in demand. It also proves an incentive to the repainting of cars, owing to the fact that the time they are out of service is reduced."

The next subject discussed was "The Cleaning of Passenger Cars and Engines at Terminals." Mr. Thomas Byrne (C. & O. R. R.) said: "For cleaning our passenger equipment at the Richmond terminal we use a force of 20 employees, 8 of whom look after the inside and 12 after the outside of the cars. We clean on an average 24 cars per day. Of these only four are cleaned daily with an oil soap which we use. The others are carefully wiped off with clean cotton waste and present usually a very neat appearance, and then the next day four of those that were wiped on a preceding day are cleaned with the oil soap, and this is continued alternately, so that at all times our equipment is looking fairly well."

The average cost of cleaning each car is $1.20.

The following was adopted:

Resolved, That it is the sense of this Association that it would be economy for all railways to regularly and thoroughly clean all its passenger equipment, cars and locomotives, at stated intervals, with some good neutral cleaner other than soap and water, and that this cleaning should be put under the immediate supervision of the master painter of the road.

In the paper on the "Best Method of Painting a Canvas Roof," Mr. H. L. Libby (West End Ry., Boston), said: "It is claimed by many that linseed oil has a tendency to rot the canvas, and that it should be well sized before the oil is applied. Possibly this is so, but it has been my practice to have the canvas set in a thick bedding composed of two-thirds lead to one-third whiting, thus forming a cement, which unites the canvas so closely to the roof boards as to become part of the same. We then prime the outside or top with an oil and lead primer. Thus we have the lead before it and lead behind it, and any decay that may take place, so far as the canvas is concerned, can do but little harm. After allowing the canvas to set as long as possible and priming to harden, we continue with the lead and oil. Thus we give a new roof five coats, as follows:

1st. One coat of thick lead and whiting.

2d. One coat of canvas.

3d. One coat of priming, lead and oil mixed thin, with slight dash of turpentine sufficient to cut the oil so that it will readily strike through the canvas.

4th and 5th. Two good coats of lead and oil paint, not forgetting a little turpentine in each coat. With this process we have never been troubled with canvas rotting, and if it should, I fail to see how it could get away. We have had old cars come to the shop to be broken up after many years of faithful service, and the canvas has been stripped off with much difficulty and sold or given to the boys to take home to cover the roof of a hen-house or some other building, there to give service for an indefinite period."

Among the other papers presented were the following: "The Repainting of Damaged Foreign Freight Cars," "How Can the Elementary Rate Fixing be Best Attained for use in Establishing Piecework Prices in the Railway Paint Shop?" "The Railway Paint Shop of Modern Times," "Is it Advisable to Rub to a Dead Finish the Interior of Passenger Cars?" "The Relations that should Exist Between the Master Painter and His Superior."

The following are the newly-elected officers: President, Charles E. Copp (B. & M. R. R.); Vice-President, H. G. McMasters (Ill. Cent.); J. T. McCracken (Jackson & Sharp Co.); Secretary and Treasurer, Robert McKeon (Erie R. R.). The vote for the next meeting place was St. Paul, 41; Montreal, 40.

ANNUAL MEETING OF THE NEW ENGLAND WATER-WORKS ASSOCIATION.

The sixteenth annual meeting of the association was held at Newport, R. I., Sept. 8, 9 and 10. About 200 members and guests were in attendance.

The convention opened at 11.30 a. m., Wednesday, with the president of the association, Mr. John C. Haskell, of Lynn, Mass., in the chair. In the course of his opening address Mr. Haskell stated as his belief that in the future legislative action would make compulsory the purification of water from surface sources.

The report of the treasurer, Mr. Geo. E. Batchelder, of Worcester, Mass., showed a balance of $2,722 in the treasury, a gain of $18 in the year. The expenses of the year were $3,323. The report of the secretary, Mr. J. C. Whitney, of Newton, Mass., showed a total membership of 549, a net gain of 20 during the year. The membership is divided by classes, as follows: Active, 464; associate, 80; honorary, 5.

Loss of Pressure Caused by Meters on a Factory Fire Supply.

The first paper read at the convention was on the "Loss of Pressure Caused by Meters on a Factory Fire Supply," by Mr. Edw. F. French, of Providence, R. I. It was largely devoted to a description of tests made or collated by the Factory Mutual Fire Insurance Cos., and started out with the general declarations that:

(1) All meters obstruct the flow of water, thus lessening the efficiency of fire streams.

(2) The moving parts of meters may stick, which in many kinds of meters so diminishes the flow as to render the fire-service pipe useless.

(3) Fish traps become clogged, thus obstructing the flow.

(4) The cost of large meters often materially increases the cost of the fire protection service or a mill, lessening the amount available for the other parts of the work, while diminishing the efficiency of the service.

In a series of tests it was found that with a flow of 500 gallons per minute, sufficient for two good fire streams, the following losses of pressure were observed for different meters: 4-in. Hersey, 40 lbs.; 4-in. Crown, 31 lbs.; 4-in. Lambert, 13 lbs.; 4-in. Torrent, 8 lbs.; 4-in. Union, 6.4 lbs.; 4-in. Gem, 4 lbs.; 6-in. Gem, 1.1 lb.; 8-in. Torrent, 0.7 lb.

With a flow of 1,000 gallons per minute losses of pressure were observed as follows: 4-in. Union, 25.5 lbs.; 4-in. Gem, 16 lbs.; 6-in. Gem, 4.8 lbs.; 8-in. Torrent, 2.8 lbs.

Blocking with wedges so the working parts could not move increased the friction as follows: 4-in. Gem, 10%; 4-in. Torrent, 15%; 6-in. Gem, 20%; 8-in. Torrent, 20%. The Crown, Hersey, Union, Lambert and Worthington meters can be blocked so that practically no water will flow through them.

Mr. French was of the opinion that but few mills or factories will really steal water, but the general sentiment expressed by the water-works officials present did not coincide with this view.

No tests of Venturi meters were made, because previous exhaustive tests have shown that they cause but little loss of head. Mr. French suggested that the brass lining of the meter should be extended far enough in all cases to prevent tuberculation within the meter. He also stated that large capacity meters of the current type will pass considerable quantities of water without registering, or with under-registration, making possible the stealing of large quantities of water in the course of time.

At the end of his paper Mr. French gave the following conclusions:

(1.) That we advise every other means for safeguarding be employed before resorting to meters.

(2.) That where a meter is unavoidable we should urge the current type, such as the Gem or Torrent, because: (a) The loss of pressure is moderate; (b) If the moving parts stick, the friction loss is not seriously increased.

(3.) We do not consider the ordinary types of disc or piston meters at all suitable for fire purposes, from the fact that they can almost completely stop the flow if their moving parts are blocked.

(4.) Where meters must be used we advise placing the meter in a by-pass, with a gate in the straightway connection. This gate should be provided with an indicator post. It is also a good plan to put gates in the by-pass each side of the meter, so the meter may be examined or repaired without interfering with the fire service.

Discussion on the paper being invited, Mr. Chas. Walker, of Manchester, N. H., said he was satisfied every mill service should be metered or something done to prevent mill companies from stealing water. "The bigger the company the more it steals."

Mr. F. L. Fuller, M. Am. Soc. C. E., of Boston, asked Mr. French if a number of small meters would be better than one large one. Mr. French replied that this would reduce friction and the chances of the whole flow being stopped by sticking, but minute streams might pass through each meter unregistered, which in the aggregate would cause a serious loss. He would suppose that water-works men would care most for such small flows as this.

Sinking Funds.

A paper with the above title was read by Mr. F. L. Fuller, M. Am. Soc. C. E., of Boston. It explained how the annual contributions for such funds are calculated, and gave some tables to aid in the work. A number of members took part in the discussion of this paper, some suggesting the desirability of investing sinking funds in local securities. Others pointed out that such funds are cumbersome and risky to manage, besides which there is always a temptation to divert them to improper uses, not always, but sometimes, criminal. Those holding these views were in favor of making bonds payable yearly, or at intervals of five years.

A Portable Electric Lamp for Night Use in Service Boxes.

Mr. Henry A. Cook, of Salem, Mass., showed a very handy device for night use in operating cut-offs to service boxes. The works at Salem are old, and trouble is often experienced in connection with the service cut-offs. A very small hand dynamo, with a little incandescent lamp at the end of a bamboo rod, the two properly connected, permits the placing of a light wherever desired in a service box. The whole device did not cost more than $10.

Some Observations on the Growth of Organisms in Water Pipes.

This paper was read by Mr. Geo. C. Whipple, Biologist and Director of the Mount Prospect Laboratory of the Water Department of Brooklyn, N. Y. The observations, however, were mostly confined to the water supply of Boston. Mr. Whipple's conclusions were as follows:

During the passage of a surface water through the pipes of a distribution system there is ordinarily a considerable reduction in the number of organisms, due to sedimentation, disintegration, decomposition and consumption by other organisms.

There is a similar decrease in the number of bacteria, except during those periods of the year when decomposition is going on in the pipes.

Growths of fresh water sponge, polyzoa, etc., are liable to occur in the distribution pipes of any surface water supply.

These growths tend to reduce the capacity of the pipes by diminishing the area of the cross-section and by increasing the friction.

By their decay they tend to the production of bad tastes and odors, though it is possible that very large amounts are necessary to give serious trouble. That these growths of sponge, "pipe moss," etc., depend upon the minute organisms in the water for their food supply and that they will die when deprived of them.

And that because of this fact these growths do not occur in pipes where the supply is a ground or filtered water free from microscopic forms.

Service Pipe Defects and the Remedy.

Mr. Geo. F. Chace, of Taunton, Mass., read a paper on the above subject, dealing more especially with the stoppage of service pipes by rust. He stated that from the expressions at previous meetings it appears that most superintendents prefer lead for service pipes, and next to this, cement-lined wrought iron, with goose neck lead connections between the iron and the corporation cock to facilitate the adjustment of grades. The objection to lead pipe is the haunting shadow of lead poisoning. Small iron pipes rust; they also fill with both rust and sediment. Cement-lined pipe gives trouble, either in itself, or in the connections.

When stoppages in services occur at Taunton the first move is to disconnect the pipe at the stop-and-waste in the cellar and run a wire through the pipe. If this is insufficient wrought iron pipe of ¼-in. inside diameter is used. If this is unsuccessful the service is dug up.

As to his own preferences for material for services Mr. Chace stated:

I have come to believe that the best service pipe at present on the market is tin-lined iron pipe. It costs more than cement-lined iron, or than lead-lined, but it is free from the perils of lead and I hope will prove more trustworthy than cement-lined wrought iron.

The discussion on this paper developed the usual variety of opinion expressed when the subject comes up before water-works men. In short, the various kinds of pipe have each been used at many places with great satisfaction and at others with contrary results, depending largely upon the character of the water. The only objection advanced against tin-lined pipe was that one member found such pipe was made years ago by expanding the tin into the iron and that rust developed between the two metals. The only objection expressed to lead was the danger from lead poisoning. Mr. W. H. Richards, of New London, Conn., stated that some 12 or 15 years ago he made a report to the association on material for service pipes, in which he stated that lead was the cheapest and best, but in exceptional cases could not be used. Two members stated that their respective local boards of health would not allow the use of lead pipe. Both Mr. Richards and President Haskell asked for citations of well-authenticated cases of lead poisoning from lead services. Mr. Richards did not believe such could be given. He did not mean long lines of lead pipe from springs, but service pipes, as ordinarily used on city works. Mr. Allen Hazen, Assoc. M. Am. Soc. C. E., of New York, referred to the reports of the English Local Government Reports for cases of lead poisoning, stating that there have been many cases where acid water acts on lead and that in some instances the water is treated to make it alkaline. Prof. Dwight Porter, M. Am. Soc. C. E., of Boston, cited a case pronounced as lead poisoning and believed to have been caused by water flowing for 1,000 ft. from a spring, the stream constantly passing through the pipe.

A Greeting from Russia.

Just before the close of the session on Wednesday evening Mr. Allen Hazen introduced Mr. Nicholas Simin, Chief Engineer of the Water-Works of Moscow, Russia. Mr. Simin responded in his native tongue, saying, as we learn from his daughter, who accompanies him as interpreter and private secretary, that he was pleased with the reception he had met and impressed with the energy, quickness and skill shown by American engineers in their work.

Reservoir and Dam No. 3, Woonsocket Water-Works.

This paper was read by Mr. Byron I. Cook, of Woonsocket, R. I. The dam is of puddled earth, 1,300 ft. long on its crest. Its maximum height is 28 ft. It has a concrete heart-wall, for a part of its length, 7 ft. 2 ins. thick at the bottom and 3 ft. at the top, extending to within 4 ft. of the crest and 1 ft. above the flow line. To save expense, the heart-wall is placed only in the highest part of the dam. For the balance of the length of the structure 2-in. spruce sheeting is used, being intended, Mr. Cook states, to serve until the interstices in the material forming the embankment are filled or stopped by silt. There is a spillway 25 ft. long and 5 ft. high in the center of the dam, designed for a 9-in. rainfall. The spillway can be supplemented by two 20-in. outlet pipes. The wet slope of the dam is riprapped clear to the crest.

Although the bed of the reservoir contained a large amount or organic matter no stripping was done, it being considered preferable to put in a filter plant. It was estimated that stripping would cost $100,000 and that about half that sum would provide a mechanical filter plant in case this should be selected in preference to slow sand filtration. Nothing has been done towards securing a filter plant, largely because of the present unsettled state of mechanical filtration.

The reservoir was drawn upon last summer and gave no trouble, although a slight growth was noticed. The water from it flows for 2½ miles through a natural channel having a total fall of 167 ft. There are some swamps in the area tributary to the reservoir, but they have always been in the drainage area drawn from, so the color to which they give rise is no addition to that in the water before the reservoir was built.

In discussing this paper, Mr. Geo. A. Stacy, of Marlboro, Mass., said that a new reservoir had recently been constructed in connection with his works in which no stripping was done except at the flow line. A prospective increase in the population of the drainage area may make filtration desirable in the future, when the money that would have been required for stripping may be used for a filter plant. For the present and the immediate future the reservoir will be drawn upon only when at its best. The water is now good.

President Haskell remarked that Boston has taken the lead in stripping reservoir sites, but he did not believe the results thus far show that the money thus spent had been used to the best advantage. The matter brought by streams into reservoirs and deposited on their bottoms may nullify the original work of cleaning. It looks as if all water supplies must be filtered ultimately, and therefore it is questionable whether it is worth while to strip reservoir sites.

Mr. Cook stated that even had his reservoir been stripped the color in the water would still remain. He thought that filtration will be demanded by the people in the future. Mr. Geo. F. Chace, of Taunton, said that color is affected by ordinary filtration (see just below) and that the Massachusetts State Board of Health objects to the use of alum, which would be required to remove color. Mr. Haskell called attention to the fact that color can be reduced by cutting off swamp areas from a drainage district, a fact demonstrated by his own experience as well as that of others.

Mr. Allen Hazen, of New York, being called on for remarks on the question under discussion spoke substantially as follows: Color in water is not unhealthful, although unpleasant. Ordinary sand filtration, at a slow rate through a thick bed, removes some color. At Lawrence, Mass., about one-half the color present in peaty water has been so removed. The amount of color removed depends on the kind of sand used, pure quartz taking out but little color, while sand containing alumina will take out more. At Liverpool, a black sand used in the filter beds for 30 years removed two-thirds, or more, of the color, but on trying a new and different sand the removal dropped to only one-third. The amount of alum required to remove the color from some peaty waters is surprising.

As to the relative cost of mechanical and slow sand filtration, on which point information was requested, Mr. Hazen stated that it was largely a matter of local conditions. A 3,000,000-gallon filter plant of the slow sand type was built under his direction last year, by day labor, 10% cheaper than the lowest bid for a mechanical filter plant.

Service Boxes.

Mr. Geo. A. Stacy, of Marlboro, Mass., gave some of his experience with service boxes. Old style boxes connected with his works, when in clayey soil, heave with the frost. After being driven down two or three times soil and stones get into the boxes, adding to the trouble. The tops are broken by heavy wagons and the boys never fail to do their part to get the boxes out of order. In well-drained sandy soil, with concrete sidewalks, the boxes give little or no trouble. The boxes should be in two parts, telescopic,and should fit tightly around the stop-and-waste. A good strong cover should be provided. The top section should extend below the frost line.

A member suggested that service boxes are generally made too light, and that some manufacturers say water-works will not pay for heavier ones. He thought a little extra expense here would be money well spent. Mr. J. B. Fish, of Scranton, said he had tried several kinds of boxes and that a good heavy ordinary iron pipe, with a cap extending down 4 or 5 ins. was the best device he had found.

The Use of Meters at Atlantic City, N. J.

Some interesting facts regarding the advantages of meters, as experienced at Atlantic City, N. J., were presented by Mr. W. C. Hawley, Assoc. M. Am. Soc. C. E., of that place. The speaker stated that prior to the purchase of the works of the two companies by the city in 1895 the rivalry between the companies had given rise to great waste of water, neither company daring to introduce measures to prevent waste for fear its patrons would go over to the other company. When the city took possession of the works the pressure was deficient at many points and it was difficult to furnish the necessary supply in the summer. Leaks in the mains and services do not make themselves apparent at the surface here, as in most other places, owing to the fact that the soil is sandy, affording excellent drainage. But few of the houses have cellars. The permanent population is about 21,000, but some Sundays at the height of the season there are 175,000 people at this seaside resort.

An enlargement of the works was recommended by Mr. Clemens Herschel, M. Am. Soc. C. E., of New York, but it was decided to try the effect of meters before following this advice. Although many services yet remain unmetered a good pressure is now maintained and the proposed enlargement of the works has not been made, except that some mains have been laid to improve the circulation and distribution. Although 600 services, or about 20% of the former number, have been added, the saving in coal has averaged one gross ton a day over that used with the smaller number of services. Had not the meters been introduced the coal consumption would have increased, rather than diminished. The total saving in coal is sufficient to pay the interest on the cost of the meters and the expense of their maintenance, besides which enlargements to the works have been made unnecessary.

The priniciple waste has been caused by hopper closets. Beer pumps also give rise to a large amount of waste, unless metered. Lawn sprinklers cause less waste than was supposed. The amount of consumption has been found to depend on the number of persons, rather than the number of fixtures, in a house.

Shutting off and turning on stop-and-waste cocks in the sandy soil causes leaks. Much of this is required, as many of the houses are occupied but a part of the year. In the cottages used only in the summer the meters are removed in the fall and stored. Where the houses have no cellars the meters are often set in boxes at the curb, or in a basement, or under the steps.

For small meters Mr. Hawley doubts if tests for accuracy with small streams are worth while. He believes it sufficient to test for accuracy with a ¼-in. stream and for registration, merely, with a 1-32-in. stream.

As to the effect of meters on revenue, perhaps two-thirds of the metered consumers pay less than under the fixture rates, but this is nearly balanced by the increased payments of those who waste or consume large quantities. The tendency is for the meters to reduce the gross revenue, but the reduction of expenses must be considered in this connection. Thus far the meter system is considered economical and satisfactory and it is intended that every tap shall be metered.

The meters are owned by the city. The meter rates have recently been placed on a flat basis of 12 cts. per 1,000 gallons and hereafter an allowance will be made to the works for water for public purposes, the sum to be raised by general taxation.

The Metropolitan Water Supply of Massachusetts.

A talk on the above subject, illustrated with lantern slides, was given by Mr. F. P. Stearns, M. Am. Soc. C. E., Chief Engineer of the Metropolitan Water Board. This work was described in Engineering News for March 7, 1895; Jan. 23, 1896, and Feb. 25, 1897, so that it will not be necessary to take it up again here. The amount of property wiped out by the big reservoir connected with this supply, Mr. Stearns thinks, will be greater than that taken for any other reservoir in the world, including villages, large mills, railway track and farms. Thus far no property has been taken by eminent domain, about two-thirds of all the property required having been bought outright.

Steel Forgings for Pumping Engines.

An illustrated talk on this subject, by Mr. H. F. J. Porter, of the Bethlehem Iron Co., South Bethlehem, Pa., closed the session on Thursday evening. Mr. Porter described in detail the process of making steel forgings of various sorts, including armor plate.

Election of Officers, Excursions and Exhibits.

On Friday morning officers were elected for the ensuing year, the principal ones being as follows: President, Willard Kent, Manager Water-Works, Narragansett Pier, R. I.; Secretary, J. C. Whitney, Water Registrar, Newton, Mass.; Treasurer, Geo. E. Batchelder, Water Registrar, Worcester, Mass.; Senior Editor of the "Journal," Jos. E. Beals, Superintendent, Middleboro, Mass.; Junior Editor, W. H. Richards, Engineer and Superintendent, New London, Conn. All the officers except the president and secretary were re-elected.

On Thursday afternoon the members and guests rode over the Ocean Drive, and Friday many of them went by boat to Narragansett Pier. The exhibit of water-works supplies was displayed to advantage in one of the wide, main corridors of the hotel, where the various appliances shown by the associate members could not escape the eyes of those in attendance. A list of the exhibits and exhibitors is given in our Construction News column.